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Journal

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AMERICAN WATER WORKS ASSOCIATION

In this issue


Hey, buddy, where's the fire?
This is no fire, officer. We're headin' for Kansas City Missouri and the A.W.W.A. Convention.
See you in Kansas City, friends, May 4 to 9. And don't forget to look in on us at Booths 77 and 78.

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New York's City Hall, completed in 1811, as it looked 100 years ago

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Characteristics and Problems of Industrial Water Supply

By Abel Wolman

A contribution to the Journal by Abel Wolman, Prof. of San. Eng., Johns Hopkins Univ., Baltimore, Md. This article is based upon a paper presented at a meeting of the American Association for the Advancement of Science on Dec. 27, 1951, at Philadelphia, Pa.

IN one of the most complex industrial societies in the world it is natural that many people are increasingly concerned with the impact which industrial water use now has and will have on one of the most important natural resources. Prophets of doom and perennial optimists confuse the public in this field as in many other areas of national import. What is known about industrial water use? What has happened to this demand during the last few decades? What kind of a commodity does industry require? What conservation deficiencies have appeared? What solutions are indicated?

It is rather generally accepted that industry uses between 20 and 25 billion gallons of water a day. There is some difference of opinion whether this amount is a reasonable indication of total industrial water use. Probably the amount represents a peacetime use prior to 1950 and no doubt actual industrial use now exceeds this figure. If the water intake for steam power purposes—normally returned to receiving bodies of water—were included, the amount would be materially increased. For the purposes of this discussion, then, it is reasonable to assume that, in 1951, industrial water use was considerably in excess of 25 billion gallons of water a day and probably represented more than 25 per cent of the total water used for all purposes in the United States. The total quantity of industrial water is more than double the amount used for general municipal purposes, which frequently receives more attention. Ten years from now this industrial use will probably have doubled, although it will

still represent not much more than 25 to 35 per cent of the total water intake of the country, as other uses, such as irrigation and steam power demands, will correspondingly increase.

Industrial use of water has in the past ten years increased by approximately 40 per cent. As in all other industrial expansion, the increase varied widely depending upon the particular industries reviewed. Whereas water use in the leather industry has grown less than 10 per cent in the last decade, the demand for water in the automobile and aircraft industries has increased approximately 80 per cent. Technological changes in existing industries and the development of new processes are perhaps the most striking causes for changing water demands, generally in the direction of increased requirements.

Characteristics of Industrial Use

Studies by the U.S. Geological Survey; by the National Association of Manufacturers in conjunction with The Conservation Foundation; by the President's Water Resources Policy Commission; by various communities; and by many individuals have all disclosed that industrial water use is increasing and that new uses come into the picture at a rapid rate. Some indication of the magnitude as well as of the variety of these demands may be obtained from data published by The Conservation Foundation (1). As in all such general compilations, the data on uses within any single class of industry show great variations within themselves because of differences in treatment, reuse, and controls. They do, however, disclose that the industrial economy of the country rests upon one commodity—water—for its existence.

In scrutinizing all data on industrial water use, one should distinguish between water pumped and water consumed. Virtually none of the reported summaries of industrial use clearly emphasizes that, as with water distributed through municipal systems, the major portion of the supply is returned to the source as discharged effluent. Although often changed in quality, it has not been consumed and, thus, is available for reuse, with or without treatment. If this distinction between pumped and consumed water is borne in mind, it will be recognized that the amount of water available for use is markedly increased.

One important characteristic of the use of water by industry is that between 5 and 6 per cent of all the industrial plants in the United States account for approximately 80 per cent of the total industrial water intake. As a corollary, more than 67 per cent of industrial plants use less than 2 per cent of the total amount of industrial water supply. The problem of conservation so far as major quantities are concerned, therefore, centers primarily on a limited number of industrial users. In general, these major users represent the following industries: [1] electrical (power generation and equipment manufacture); [2] pulp and paper; [3] petroleum products; and [4] steel. These considerations point to the fact that the most useful conservation approach, perhaps bringing the greatest return per unit of energy or money expended, would be to concentrate upon the 5 or 6 per cent of the total manufacturing units in the United States. This does not mean, of course, that attention might not and should not be devoted to the remaining 94 or 95 per cent of the plants which use less than 10 mgd each or to the 65

per cent using less than 250,000 gpd each. Virtually all experience has shown that conservation practices may be profitably introduced in the small as well as in the large consumer groups, although greatest return is to be expected from the relatively few largest users.

Availability of Water

The tremendous use of water for industrial purposes even in peacetime naturally has given rise to the question of whether or not present and foreseeable future demands can and will be met from existing water resources. This question has not only been posed, but has been carefully analyzed by a number of private and public investigators, one of which is the U.S. Geological Survey. Only one conclusion may be drawn from these diagnostic reviews—namely, that potentially available resources are considerably in excess of foreseeable future demands, at least for 100 years.

The records of the U.S. Geological Survey show that, on the average, 30 in. of precipitation falls annually on the United States. Somewhat less than 25 per cent of this amount appears in runoff over the surface of land or into the subsoil. The amount now used directly by man annually represents only about three-quarters of an inch of rainfall, leaving a residual flow, surface and underground, of a little less than 7 in. Thus, the volume of water which might be made available for public and industrial uses is high. Its development necessarily must wait upon need and upon intelligent programming of works essential for supplying such needs.

Such shortages as have occurred within the last decade, for example in New York City, have been widely attributed, by people who should know better, to a dwindling potential resource. Careful review of the New York City water supply situation (2) discloses, without question, that the shortage was entirely the result of delay in providing the physical facilities essential for delivering increased quantities, and not unavailability of water. This delay was man-made and was the result of a long series of fiscal and social dilemmas, such as a major economic depression, a serious world war and local municipal fiscal stresses. None of these causes was even remotely related to the absence of available water resources. Water is abundant in the New York area and is economically available for uses far in excess of those now anticipated for the long distant future.

It is fruitless, therefore, to postulate that every water dilemma which occurs in the United States is caused by a dwindling resource. In fact, it is even dangerous to do so, since it necessarily diverts attention from the real problem, which is one of diagnosis, vision, program, development, and conservation.

It is true, of course, that in some areas in some regions of the United States the potential of water development is low. In other areas, development has exceeded available resources to a dangerous degree. In still others, locally, water is damagingly excessive. In other words, in no two parts of the United States may industrial water or its availability be viewed in the same way.

This country is one of high diversity of geography, geology, topography, and climate. Those who search for industrial water in large amounts in areas where the total annual rainfall is less than 10 in. must remember that water

can only be developed or imported at high cost and in competition with other regions where more economical supplies are available. It is axiomatic that "there isn't any more water than there is" or than is precipitated. Other bases for estimate in the miraculous sphere invite failure.

Since it is undoubtedly true that the water resources of the United States are ample in quantity but highly variable in location, the water planner must devote perhaps most of his attention to the immediate problem of obtaining water supplies adequate in quantity and quality as demands arise from day to day. To accomplish this purpose successfully, without undue loss of time and with due regard to economics, a great deal needs to be done. It is to this problem that this discussion is primarily directed, because, in the solution of this programming, a number of subtle and difficult issues arise.

Bases of Industrial Water Supply Problems

Given the assumption that water, by and large, is available in those areas in which nature has provided reasonably adequate amounts of rainfall, why is it that problems of industrial water use arise? The more important reasons appear to be as follows:

1. *Delay in Execution*

In general, there is a long lag between the planning of a community water development and its initiation and construction. Where industry is dependent upon the public water supply, this difficulty most frequently arises. The communities most often cannot assume long-range fiscal obligations for supplying industrial water when the demand is not obvious, guaranteed, or reasonably continuous. Even when the demand is obvious, the time the average community takes for developing and executing a program is likewise generally long. At least ten to fifteen years elapse between idea and accomplishment. This delay is merely a reflection of the fact that municipal bodies move slowly, not only because bond issues always must carry conviction to the electorate, but because legal and fiscal restraints are many and time-consuming for compliance. It is noteworthy that, just as often as not, industry within the community is as much responsible for such delays as the general taxpayer.

2. *Deficiencies in Distribution*

Often a community's water stringency arises because of restrictions in facilities other than sources, such as pumping equipment, treatment plants, and transmission and distribution lines. Their installation and expansion require large amounts of money, yet their significance in relation to industrial demand is most difficult to make clear to the average citizen and sometimes to the average industrialist. Even when sources of supply are available, real difficulties in industrial service result from inadequacy of the facilities that deliver the supply from those sources.

3. *Absence of Social Organization*

Where industrial water use is dependent both for diagnosis and for development on nonexistent political units, such as a municipality, a water district, or any form of public corporation, however, delay in execution is even greater. Joint private and public efforts toward providing increased water are notable for their rarity. Exceptions, of course, appear—for instance, in Texas and in developments in the Birmingham, Ala., area, where private

industries for many years pooled their water resources and provided this commodity. Such planning is not practiced as much as it should be both for development and for conservation.

In Germany, particularly prior to World War II, the participation of private industry in water resources development and conservation had been practiced for more than a quarter of a century. This participation has been broad and legally sanctioned, covering voting membership in the financing and administration of the water districts. The functions which have been performed by such districts have run the entire gamut from water supply use to waste treatment. The technological developments have been large and imaginative. The policies and practices which have led to such extensive industrial participation in water resources development and conservation, in the various river districts of the Ruhr, Emscher and others, could well be intensively explored for whatever values and precedents they may have for us.

The significance of failure to provide, through appropriate enabling legislation, administrative and fiscal organization for the development of industrial water supply cannot be overemphasized in this discussion. Unless the industry is large and capable of undertaking its own water development on a strictly private basis, this factor is critical. Broad legal provision for the devices by which to accomplish the function of industrial water supply is still deficient. It is an area of effort that needs to be canvassed by official state and federal agencies in order to provide both the imagination and the machinery to smooth the way for further water resources development by local units or groups of units. This lack is particularly significant because general water resources development of today is a far more complex undertaking than it was a quarter of a century ago. Industrial water use now has to be integrated into river basin development of such magnitude and complexity that both imagination and machinery for financing, administration, and repayment must be developed to a high level of proficiency and equity.

Although the "water district" plan has been successfuly used in a number of areas in the United States, the coverage of the country is surprisingly limited. A low record of skillful solution of such problems as are discussed here is offered by the Washington Suburban Sanitary District, the Boston Metropolitan District, the East Bay (Oakland, Calif.) group, and others. In spite of this record, such duly constituted agencies, with powers to issue bonds, to construct and operate water systems, to establish rates, and to collect revenue in areas where no single authoritative political unit is operative, have not been widely established.

The nature of this deficiency is illustrated by the findings in a recent study (3) of water requirements for the industrial area of Baltimore, Md. The authors of this report make the pertinent comment: "In the case of the development of a large surface supply, some administrative, engineering, and fiscal agency would be required both for development and for sale of water. Such an agency is not now in existence and its creation might require legislative action."

4. *Reuse of Water*

The reuse of water by industry, even in areas where water is ample, has not been as wide as one might hope (4). Sometimes this failure to reuse water

results not from too little of this commodity but perhaps from too much. Often it is assumed to be unprofitable to reuse some of the water now discarded. Such reuse is not always possible, but frequently this aspect of water conservation, if not ignored, is at least not too seriously observed.

In a few instances, such as in the Mahoning Valley of Ohio, successful reuse by a series of industries has led to difficulties, both in increased temperature and in deteriorated quality of river water. The procurement of additional quantities of water is a necessity of long standing. The anticipation of such problems by concerted and continuing review is one of the challenges in many areas of this country. It illustrates again the absence of any machinery, private or public, by which to anticipate and to correct these difficulties. This kind of a situation is not peculiar to the United States. It is apparent in most industrial countries and is merely a reflection of the fact that situations usually have to become worse before they become better.

In reviewing the water problem in England several months ago, the author noted that the water temperature of the River Thames had increased from 11 C to more than 15 C, whereas the dissolved oxygen dropped from 40 to less than 5 per cent of saturation in a period of 54 years (5). This situation has been apparent for a number of years and there has been much discussion of the difficulty. Corrective action on any broad basis, however, did not precede deterioration.

5. *Artificial Recharge*

Although a few examples of the return of water to the soil for artificial rehabilitation of underground waters are available in this country, particularly on the Pacific Coast and to some extent in the Louisville, Ky., area, the application of this technique on a broader regional base has not been rapidly extended. Its importance for industrial purposes, such as cooling water, cannot be overemphasized, because of the natural advantages which result from the lower temperature of water from underground sources. Despite this fact, however, experimentation with controlled water spreading is not too frequent. Its complexities are, of course, well known, geographically, topographically, and from the standpoint of land culture. Exploration of its potentialities, however, lags. Stimulation of such diagnostic undertakings should be one of the major efforts of official agencies.

When, in World War II, the War Production Board attempted to initiate similar activities in industry, in order to conserve ground water for wider application in water distressed areas, acceptance of the idea was limited.

6. *Reclamation of Waste Waters*

Similar comment may be made on the failure to utilize to the maximum the waste waters resulting from municipal and industrial usage. The record discloses a number of such applications for agricultural use, but examples of major industrial reuse of processed sewage and industrial waste are few in number and small in total quantity.

The practices at the Bethlehem Steel Co. plant (6) in Maryland, at the Fontana Steel Co. in California, and of certain industries in Corpus Christi, Tex., although paralleled by a few

other industries, have not led to any extensive reuse of a precious "sullied" resource. In fact, in some areas, where water is at a premium and is brought in at great expense, it is interesting to observe with what care and at what cost the "used" water is carefully led into the nearest river or ocean for disposal. At the same time, industry in the area searches with equal care for more industrial water. Here, again, complexities of a technological nature are great, although often not insurmountable. Militant imagination is sometimes at low ebb.

7. Ground Water Control

In the use of ground water the general practice appears to be to exhaust the resources by one or more methods before attention is given to its total conservation. Professor Thomas in his recent volume on conservation (7) makes quite clear that the problems of ground water in the United States are of a highly variable character. He emphasizes that in some areas water is scarce, whereas in others it is even damagingly abundant. In his analysis of a large number of critical ground water areas of this country, it is soon apparent that virtually no area parallels any other in the similarity of causes of difficulty. He points out that no single generalized approach toward conservation is indicated. At the same time, it is obvious that, in virtually all of the areas, intelligent diagnosis, development, and control are not apparent. Each of the areas which he canvasses in detail presents a picture of more or less of a vacuum insofar as administrative and technological review is concerned. All gradations of diagnosis and control appear, but only infrequently is comprehensiveness of attack evident, either by governmental, voluntary, or private groups.

In ground water as in surface water problems, solutions wait upon private and public imagination and research and upon the development of administrative and fiscal machinery. The maintenance of an adequate balance between sufficient exploitation, to permit industrial advance, and abuse, resulting in ground water depletion, demands a high level of water development statesmanship.

Conclusions

From all of these experiences the lessons to be learned are primarily those pointing to the necessity of:

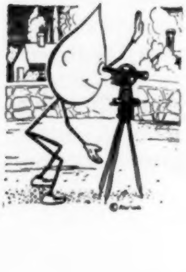
1. Providing more flexible and prompt inventory of water resources.
2. Laying greater emphasis upon ingenuity in the use and reuse of water and of wastes
3. Extending or creating machinery for investigation, development, and conservation of both surface and ground waters.

The provision of these facilities transcends by far the necessity of accumulating new knowledge. Although it is true that emphasis on industrial waste treatment and on stream pollution abatement, for example, is essential, it is equally true that, if these solutions were all available, the problem of industrial water use and conservation would still remain. The overlying problems rest for their solution upon developing inventories, long-range programming, and the creation of administrative and fiscal machinery to convert plans and programs into structures for use. These latter challenges cannot be met by some hypothetical hierarchy. They must be met, in general, locally—

with the maximum participation, however, of the rich multiple forces available in this country on federal, state, and local levels, and in private industry. The job of summoning up these resources of private and public nature and of integrating them into the kind of long-range diagnosis and plan discussed herein is difficult, but not impossible.

References

1. *Water in Industry.* National Assn. of Manufacturers & The Conservation Foundation, New York (Dec. 1950).
2. ENGINEERING PANEL ON WATER SUPPLY. Future Water Sources of the City of New York. Mayor's Commission on Management Survey of the City of New York (July 1951).
3. WOLMAN, ABEL; POWELL, S. T.; & REQUARDT, G. J. Report on Water Supply for Industrial Area, Baltimore, Md. Baltimore Assn. of Commerce (July 31, 1951).
4. WEAVER, PAUL. Water Makes Jobs for Workers. Unpublished paper presented to Annual Meeting, Texas Water Conservation Assn., Austin (Oct. 1, 1951).
5. *Water Pollution Research—1950.* Water Pollution Research Board, Dept. of Scientific & Industrial Research, London (1951).
6. WOLMAN, ABEL. Industrial Water Supply From Processed Sewage Treatment Plant Effluent at Baltimore, Md. Sew. Wks. Jour., **20**:15 (Jan. 1948).
7. THOMAS, HAROLD E. *The Conservation of Ground Water.* McGraw-Hill Book Co., New York (1951).



National Water Resources Policy Recommendations

By Samuel B. Morris

A statement by Samuel B. Morris, Gen. Mgr. & Chief Engr., Dept. of Water & Power, Los Angeles, Calif.

The President's Water Resources Policy Commission, of which Mr. Morris was a member, was appointed in January 1950 and submitted its report and recommendations in a series of three volumes issued between December 11, 1950, and February 26, 1951. A summary of the general recommendations was published in the February 1951 issue of the JOURNAL.

Meanwhile, on February 12, 1951, the commission, in fulfillment of instructions at the time of its appointment, submitted to the President, in the form of a proposed bill, a series of legislative recommendations which were not made public until more than a year later, on February 18, 1952. A summary of this proposed legislation follows Mr. Morris' statement of the philosophy upon which it was based.

WATER and land properly husbanded are permanent natural resources upon which the very life of our nation and future generations must depend. Once consumed, other mineral resources are no longer available, but water and land properly used are permanent assets. Because this simple but vital distinction has not been understood, we have seen the loss of much of our forests, fish, and wildlife and serious erosion of the soil as a result of man's occupation of the land. We must, indeed, continue to look to the private enterprise system for the most efficient exploitation of natural resources. At the same time, we must look to government at all levels for the conservation of natural resources and, most of all, of the resources of water and land. Natural resources and human resources are the source of the nation's wealth and strength.

From this viewpoint, we cannot, in the manner of large-scale business enterprises, apply the test of financial feasibility alone to the works which are needed for the conservation and use of these absolutely vital resources. Our dependence upon water and land resources for life itself makes it necessary to consider the effects of projects upon the whole economy and life of the nation.

Sometimes the best interest of all the people is met by social decisions that may in part be contrary to pure economic theory or fail to meet the test of financial feasibility. It is more important socially, for example, to have an abundance of forests that would make timber products generally available at low cost than to have limited forests that would result in shortage of timber products, even though the net earnings by the timber industry might be greater under shortages.

Commission Recommendations

Based on this concept, the recommendations of the President's Water Resources Policy Commission are not merely negative—that is, they do not state merely that certain work should not be done unless certain standards of feasibility are met. They are affirmative, declaring that action is required to conserve water and land for their best continuing use. The commission's report cited the experience of the last two decades, beginning with the Boulder Canyon Project and the construction of Hoover Dam and further exemplified by the Central Valley Project of California, the Tennessee Valley Authority, and many other coordinated projects, all indicating that the greatest benefits to the economy arise through multiple-purpose developments. Such major developments on our principal rivers require comprehensive coordinated planning which takes into account the requirements of the entire river basin.

To carry on such plans and programs adequately there is necessity for adequate basic data, which should be continuously secured, compiled, and made available. Continuous studies are also required to develop the country's need for food and fiber and the proper timing of these great projects to improve the regional and national economy.

Although the commission outlined certain recommendations for the return of costs, it did not fully define standards of feasibility. Instead it proposed a plan under which there should be strict accounting—projectwise, basinwise, and nationwise—for cost of construction, operation and maintenance, and capital, including interest. It proposed the appraisal of benefits, tangible and intangible, for only by considering both can the total picture be made clear. It recommended the allocations of cost among navigation, flood control, irrigation, power, domestic water supply, and other uses, in accordance with full presentation of the facts and principles.

It proposed that contribution to cost be made by all those benefited, including persons, corporations, states and local governments, including irrigation districts, soil conservation districts, drainage districts, and special conservation districts, and by the federal government. It is believed that such contributions to cost by all persons and agencies benefited would decrease the kind of logrolling appropriations which all too frequently are sought by those who benefit but pay no direct costs. It is believed that full honest revelation of costs and benefits would be an effective means of screening the desirable from the undesirable projects.

To plan and program the water and related land use development of river basins, it was proposed that river basin commissions with representation from state and local governments be created. Opportunities for hearings in the field and official comments by state and local governments should insure careful, well-drawn plans and properly analyzed programs. Creation of a board of review at the national level, to review all such plans and programs, to aid in establishing uniform standards of feasibility, and to submit recommendations to the President and Congress would be a further means of assuring the undertaking of the best and most soundly

conceived programs under uniform standards of feasibility. Finally, projects would be authorized only by the Congress, which, under our democratic process, would offer final opportunity for public hearings and expression of public reaction on a nationwide basis.

General acceptance of these principles as a guide to sound planning and development of our water and land resources will mean a long step forward in conserving, and using without waste, the great supplies of water which nature has given us.

Importance of Education

There are at the present time many enthusiastic advocates of conservation of forests, topsoils, fish and wildlife, and recreational opportunities. On the other hand, many favor construction of major dams, power plants, channels, revetments, drainage works, canals, and aqueducts as the only type of water development activity. These sometimes conflicting conservationists must see the whole problem and work together for better programs. It was the commission's firm belief that there is nationwide need for intelligent, educational effort directed toward better understanding of the interrelationship of forest, grazing land, and tilled land, with the best coordinated basin-wide construction programs of river improvements on multiple-purpose bases thereby to assure greatest permanence and protection to water and land resources at the greatest economy in their development and utilization. Only by such awakening of an informed citizenry may there be certainty of intelligent development and administration of the water and land resource base necessary to keep the nation strong and its people prosperous.

Local Participation

Under existing laws, state and local participation in coordinated river basin plans, programs, and projects is limited to the right of citizens to communicate and to present testimony at local hearings or before the Congress at committee hearings on bills at Washington. In certain projects affecting states, the states involved may file an expression of views with the secretary of the department under which the project will be constructed. Subject to certain state and federal laws, of course, states, local agencies, and corporations may themselves plan and build projects affecting rivers, but no direct voice or participation in federal programs is generally provided to the states and local agencies of government. There has, however, been a growing tendency in larger basin-wide programs such as that of the Missouri River Basin toward establishment of advisory bodies, representing state and local interests, to meet with federal interagency committees representing each of the six major departments interested in the planning, programming, and development of the basin.

The instructions from the President to the Water Policy Commission were that matters of government organization should be left to the Hoover Commission for study and recommendation and that its recommendations should be limited to matters of water policy and related land uses. Both in its report and its draft of proposed legislation, therefore, the commission recognized the existence of interested federal agencies and attempted to provide a place for representatives of each on

the drainage basin commission formed to plan and program the development of each major basin or group of basins. Such basin commissions would have state as well as federal representation and would be instructed to seek the advice, assistance, and cooperation of the people residing within the basin and to hold local hearings. To implement local cooperation, further provision is made for an advisory committee of 25 citizens in each basin named by a governor or conference of governors and by local government.

A drainage basin commission would include: one representative from each of the six federal agencies; two selected by the basin advisory committee; and one resident of the area to be named by the President, making nine in all. If the recommendation of the Hoover Commission Report or its task force were adopted by the Congress, the federal representation would be reduced and a better balance of federal and local membership would result. In any event, this appears to be the first time in federal water and land use development, that any provision has been made for state and local representation having direct participation and authority.

APPENDIX

Excerpts From the Proposed Water Resources Act of 1951

A Bill To provide for safeguarding and improving the development, utilization, and conservation of water resources, including related uses of land, through unified planning and action on a comprehensive multiple-purpose basis in cooperation with states and local governments, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled:

Sec. 1—Short Title

That this Act may be cited as the "Water Resources Act of 1951."

Sec. 2—Purpose

In order to protect and promote the general welfare of the United States, commerce among the several states and with foreign nations, beneficial use of federal property, and the security and defense of the United States, it is the purpose of this Act to establish a sound national water resources policy for uniform application to all federal participation in the development, utilization, and conservation of water resources, including related uses of land, comprehending, but not limited to, the following beneficial purposes: aid in conservation treatment of all watershed lands; control of floods and beneficial use of flood waters; protection and improvement of navigation; reclamation of lands through irrigation, drainage, and other means; development, generation, transmission, and disposal of electric power; development and improvement of domestic, municipal, industrial, and other water supply; control of pollution; control of sedimentation; control of salinity; preservation and enhancement of fish and wildlife resources; development of recreational opportunities; and protection of shores from erosion.

Sec. 3—Policy

The future and strength of the United States depending directly upon conservation through the efficient development and wise use of the water and land resources

of the Nation, it is declared to be the policy of the Congress that:

3(a) The river system and its watershed shall be deemed a single resource unit—the river basin—which, in whole or in part or in combination with other basins or portions of basins as provided for in this Act, shall constitute a unit for federal participation in the development, utilization, and conservation of water resources, including related uses of land.

3(b) In order to provide a broader base for an expanding national economy, such federal participation shall be based upon adequate and reliable data and shall be so planned and prosecuted on a comprehensive multiple-purpose basis as to achieve maximum sustained usefulness of resources for all beneficial purposes which may be served consistently with this Act.

3(c) Such federal participation shall be so planned and coordinated by River Basin Commissions and the Federal Board of Review, as hereinafter provided, as to assure: the safeguarding of the Nation's resource base against deterioration by careless use or neglect; the improvement of that resource base through positive and specific plans and action designed to meet the expanding requirements of the Nation; regional economic development; the maximum in material and cultural benefits; opportunity for farms, urban homes, commercial establishments, and industries to secure the full advantage of abundant supplies of electric power so marketed as to encourage the most widespread use thereof at the lowest possible rates to consumers consistent with sound business principles; and the greatest possible contribution to the general welfare of the United States, commerce among the several states and with foreign nations, beneficial use of federal property, and the security and defense of the United States.

3(d) In order to carry out the purpose of this Act, including assurance of uniform application of evaluation, authorization, and reimbursement standards, no proposal for or respecting any new examination, investigation, survey, study, plan, design, project, activity, program, budget estimate, or request for funds for or incidental to the development, utilization, or conservation of water resources, including related uses of land, shall, from and after ...., 195.., be deemed authorized, or be submitted to the Congress by any federal agency except in conformity with the provisions of this Act.

3(e) With the advice, assistance, and cooperation of the people in the river basins and their state and local agencies, it is the duty of the federal government to exercise the powers conferred upon it by the people of the United States to assure so far as possible maximum sustained usefulness of water and land resources for all beneficial purposes, thereby to aid in guaranteeing the future and strength of the United States.

Sec. 4—Definitions

[Contains the necessary definitions.]

Sec. 5—River Basin Commissions

5(a) To carry out the provisions of this Act, the President is authorized and directed to create, prior to ...., 195.., not to exceed fifteen River Basin Commissions to plan and coordinate all federal participation in resource development within or bordering all states of the United States, except as provided in Section 19(b) of this Act, and to define, and within his discretion to redefine, the territorial jurisdiction of each such Commission which shall, so far as practicable, conform to the natural boundaries of river basins: *Provided, however,* That where it is necessary or desirable to carry out the purpose and policy of this Act, such boundaries may include one or more portions of one or more river basins.

5(b) Each Commission shall consist of nine members. One member shall be an officer or employee of the Corps of Engineers, United States Army, who shall be appointed by the Secretary of the Army;

one member shall be an officer or employee of the Department of the Interior, who shall be appointed by its Secretary; one member shall be an officer or employee of the Department of Agriculture, who shall be appointed by its Secretary; one member shall be an officer or employee of the Department of Commerce, who shall be appointed by its Secretary; one member shall be an officer or employee of the Federal Power Commission, who shall be appointed by its Chairman; one member shall be an officer or employee of the United States Public Health Service, who shall be appointed by the Federal Security Administrator. Two members shall be elected by an Advisory Committee, as provided in Section 7(e) of this Act, and each such member shall, at the time of election, be a resident within the territorial jurisdiction of such Commission. The ninth member, who shall be Chairman, shall be appointed by the President with the advice and consent of the Senate, and such member shall, at the time of appointment, be a resident within the territorial jurisdiction of such Commission.

5(c)–(g) [Establish terms of office, compensation of members, quorum, and places of business.]

Sec. 6—General Functions of River Basin Commissions

6(a) As more fully provided hereinafter, each Commission is authorized and directed, among other things, to prepare and keep up-to-date a Twenty-Year Advance Program for federal participation in resource development within its territorial jurisdiction, to submit annually a request for authorization of such projects and activities, in addition to those already authorized, as in its judgment may be effectively undertaken during the succeeding six years in harmony with the provisions of this Act, to prepare an Annual Resource Budget showing funds needed for prosecution of authorized projects and activities, and to keep and maintain a Uniform System of Accounts.

6(b) Each Commission is authorized and directed to coordinate the functions, within its territorial jurisdiction, of all federal agencies so far as they relate to resource development, and each Commission shall take such action as may be necessary or appropriate to accomplish such coordination with the objective of assuring that all such functions are so carried out on a comprehensive multiple-purpose basis as to achieve maximum sustained usefulness of resources for all beneficial purposes. To this end, all such federal agencies are authorized and directed to cooperate with each other and with the Commission and to comply with such coordination requirements as the Commission may prescribe.

6(c) In order to carry out the purpose and policy of this Act, each Commission is authorized and directed to maintain a continuing survey of all federal legislation and functions relating to resource development within its territorial jurisdiction. Not less often than once a year, beginning October 1, 195.., each Commission shall submit a detailed report to the Board recommending specific legislative changes or additions which, based on its judgment and experience, it deems desirable for achievement of the purpose and policy of this Act, including the elimination of inconsistencies, conflicts, duplications, and gaps in the powers, duties, and responsibilities of the federal agencies participating in resource development, and such report shall specify any relevant federal function which the Commission deems should be modified, transferred, merged, or abolished.

6(d)–(f) [Authorize appointment of non-Civil-Service personnel and performance of necessary and appropriate functions; and require an annual report.]

Sec. 7—Participation of State and Local Interests

7(a) Each Commission shall, to the maximum extent practicable, seek the advice, assistance, and cooperation of the people residing within its territorial juris-

diction and of their state and local agencies in carrying out the provisions of this Act. To this end, it shall arrange for consultation and interchange of views with an Advisory Committee, as provided for in this section.

7(b) Within a reasonable time prior to such date as may be fixed by the President for appointment of the nonelective members of the several Commissions, the President is authorized and directed to arrange for conferences of governors; or their duly designated representatives, for the purpose of establishing such Committees for the several Commissions. Such a conference shall be arranged as to each Commission, and an invitation shall be extended to the governor of each state lying wholly or in part within the territorial jurisdiction of such Commission. A like conference shall be arranged at the end of each third year thereafter for the purpose of reconstituting each such Committee.

7(c) Each Committee shall consist of twenty-five members, all residents within the territorial jurisdiction of the Commission. The governor of each state lying wholly or in part within the territorial jurisdiction of the Commission shall be invited to appoint one member. Under such rules and procedures as it shall determine, each conference of governors is authorized to elect the following Committee members: three representing agriculture; three representing business; three representing labor; three representing fish, wildlife, and recreational interests; and such number of representatives of local governments as may be required to bring the total Committee membership to twenty-five.

7(d)–(f) [Establish committee terms of office, meeting time, and officers.]

7(g) Each Commission is authorized and directed:

7(g)(1) to consult with and be consulted by its Committee in the formulation of the Commission's Twenty-Year Advance Program and to encourage such Committee's assistance in seeking coordination between such Program and the operations of states and local governments for or incidental to resource development;

7(g)(2) to encourage the assistance of its Committee in the negotiation of agreements with states and local governments, as provided for in Section 14 of this Act, to the end that, where direct charges are impracticable, primary and secondary beneficiaries may aid in reimbursement of costs through the operation, under state law, of conservancy or other similar districts or through the application of such other power or authority as may be available to such states and local governments;

7(g)(3)–(h) [Authorize paying Committee expenses and obtaining opinions of public through public hearings.]

Sec. 8—Federal Board of Review

8(a) In order to coordinate the functions of the several Commissions, to prescribe uniform standards of evaluation, authorization, and reimbursement, to assure uniform application of such standards, to provide the President and the Congress with advice and recommendations respecting federal participation in resource development, and otherwise to assist in carrying out the purpose and policy of this Act, there is hereby created in the Executive Office of the President a Federal Board of Review consisting of five members who shall be appointed by the President with the advice and consent of the Senate.

8(b)–(c) [Establish terms of office and compensation of Board.]

Sec. 9—General Functions of the Federal Board of Review

In addition to other functions specifically provided for elsewhere in this Act, the Board shall perform the following general functions:

9(a) To coordinate the functions of the several Commissions and to assure uniformity in the exercise of those functions, the Board is authorized and directed to prescribe, issue, and make, within six months after its organization,

and thereafter within its discretion to amend or rescind, such regulations as it may find necessary or appropriate to specify the procedures and standards which Commissions shall follow in accomplishing the coordination provided for in Section 6(b) of this Act.

9(b) Each request by a Commission for authorization of any examination, investigation, survey, study, plan, design, project, activity, or program, shall be submitted to the Board for its analysis and review with respect to, among other things: any engineering considerations; economic feasibility and benefits to the public, particularly in relation to ultimate costs; and the relationship of such request to such Commission's Advance Program, to similar requests by other Commissions, to the National Annual Resource Budget, to the comparative figures provided for in Section 13(c) of this Act, and to the purpose and policy of this Act.

9(c) Whenever the Board shall find any such request deficient in respect of any consideration referred to in Subsection (b) of this section, it shall return such request with a statement of its views thereon to the Commission, which shall make such modifications and comments as it deems appropriate, and resubmit the request and its comments within such time as shall be specified by the Board.

9(d) After final review and analysis of all annual requests for authorizations, the Board shall consolidate such requests, prepare its report thereon, and submit such consolidated requests and report to the President for transmission to the Congress. After final review and analysis of an exceptional request for authorization, the Board shall promptly submit the same with its report thereon to the President for transmission to the Congress.

9(e) The objectives of analysis and review by the Board, as provided for by Subsections (b), (c), and (d) of this section, shall include: coordination of all relevant functions, interests, and purposes during the formulation of plans and programs; assurance of comprehensive multiple-purpose resource development designed to achieve maximum sustained usefulness of resources for all beneficial purposes; recommendations for priorities of undertakings within proposed programs, based upon sound appraisals of need; recommendations for authorizations and appropriations, based upon sound determinations of economic and engineering feasibility; recommendations designed to assure effective integration of all phases of federal participation in resource development within the territorial jurisdiction of each Commission and throughout the Nation; and any other recommendations to carry out the purpose and policy of this Act. As an aid to accomplishing these objectives, the Board is authorized and directed to maintain continuing liaison with each Commission.

9(f) In order to carry out the purpose and policy of this Act, the Board is authorized and directed to maintain a continuing survey of all federal legislation and functions relating to resource development, to analyze and review the reports submitted by each Commission as provided for in Section 6(c) of this Act, and to submit not less often than once each year beginning January 1, 195.., a detailed report to the President for transmission to the Congress, recommending legislative changes or additions which, after considering the recommendations of all Commissions and based on its judgment and experience, the Board deems desirable for achievement of the purpose and policy of this Act, including the elimination of inconsistencies, conflicts, duplications, and gaps in the powers, duties, and responsibilities of the federal agencies participating in resource development, and such report shall specify any relevant federal functions which the Board deems should be modified, transferred, merged, or abolished.

9(g) In order to provide a sound basis for its own evaluation procedures and those of the several Commissions, and for the information of the President and

the Congress, the Board is authorized and directed to compile and maintain technical, economic, and statistical data for the purpose of appraising the several Commissions' Advance Programs and their constituent projects and activities, such data to include information as to the estimated and actual costs, benefits, and reimbursement, and information as to the degree to which resource development has achieved the purpose and policy of this Act.

9(h) The Board is authorized and directed to review periodically all authorized federal projects, activities, and programs for or incidental to resource development and from time to time to submit to the President for transmission to the Congress a report on the advisability of initiating, continuing, or modifying any one or more of them.

9(i) In December of each year, the Board shall submit to the President for transmission to the Congress a report covering the operations of the Board during the preceding fiscal year, and such report shall include a comparative summary of the operations of each Commission during such fiscal year.

9(j)–(l) [Authorize appointment of non-Civil-Service personnel and performance of necessary and appropriate functions, and require cooperation of federal agencies involved.]

Sec. 10—Advance Programs

10(a) Each Commission is authorized and directed to cause to be made comprehensive surveys and studies within its territorial jurisdiction and to prepare, as rapidly as practicable and within not more than two years after its organization, a comprehensive Twenty-Year Advance Program for all federal participation in resource development within its territorial jurisdiction in harmony with the purpose and policy of this Act. Such Program shall thereafter be kept up-to-date by means of at least an annual revision and shall continuously cover a period of twenty years beyond each such revision.

10(b) Each Commission is authorized and directed to utilize the services of any federal agencies in the conduct of so much of such surveys and studies as relates to the functions of each such agency; and each such agency is authorized and directed to furnish such services and to aid the Commission in the preparation and revisions of its Advance Program.

10(c) In accordance with such regulations and procedures as the Board may prescribe, such Advance Programs shall:

10(c)(1) be so planned for prosecution on a comprehensive multiple-purpose basis as to achieve maximum sustained usefulness of resources for all beneficial purposes;

10(c)(2) describe, in such detail as may be practicable, each constituent project and activity in such a manner as to show the essential physical and economic characteristics of each, including its contribution and relation to the Advance Program and to resource development;

10(c)(3) reflect the Commission's judgment of the priority in importance and scheduling of each constituent project and activity;

10(c)(4) specify in detail the manner in which each constituent project and activity and such Advance Program as a whole conform to the purpose and policy of this Act;

10(c)(5) specify, in such detail as may be practicable, with respect to each project and activity within such Advance Program, the Commission's estimate of the expenditures required for the completion of each such project and activity and of the reimbursement to be returned to the United States therefrom; and

10(c)(6) specify, in such detail as may be practicable, with respect to each project and activity relating to federal participation in resource development within the Commission's territorial jurisdiction, including those existing, those authorized, and those for which authorization is or will be sought:

10(c)(6)(i) The Commission's estimate of the capital expenditures and operation and maintenance expenditures re-

[illegible]

Sec. 11. Authorizations

[illegible]

Sec. 12. Evaluation

12(a) Each request by a Commission for authorization pursuant to Section 11 of this Act shall be accompanied by an evaluation set forth on a standard form of Investment Appraisal Statement. The Board is authorized and directed, in cooperation with the several Commissions, to develop and prescribe, and within its discretion to revise, uniform standards and methods for evaluation and a standard form of Investment Appraisal Statement. Each evaluation by a Commission and each report thereon by the Board shall conform to such standards and methods and shall be set forth on such Statement.

12(b) *Investment Costs:* Such Statement shall include dollar estimates of the following investment costs:

12(b)(1) Direct: examinations, investigations, surveys, studies, designs, and plans; land acquisition, rights-of-way, and utility replacement; construction; administration and overhead; use of money; and any other direct investment cost measurable in dollars.

12(b)(2) Indirect: displacement or relocation of population; loss of land and minerals; and any other indirect investment cost measurable in dollars.

12(c) Annual Costs: Such Statement shall include dollar estimates of annual costs on the basis of amortization of the total direct and indirect investment costs within 50 years, with interest at the current federal long-term borrowing rate. Such annual costs shall include: operation and maintenance, including administration, overhead, and payments to states and local governments; replacements; interest and amortization; increase in the annual cost of maintaining and operating existing public services; and any other annual cost measurable in dollars.

12(d) Annual Benefits: Such Statement shall include dollar estimates of the following annual benefits:

12(d)(1) Primary: increase in net income from land made possible by conservation treatment of watershed lands; reduction in flood damage and increase in net income from property made possible by flood control; savings in transportation costs on existing traffic by waterways as compared with movement by alternative means, and similar savings in cost of moving new traffic made possible by navigation improvements; increase in net income from additional production of farm products made possible by irrigation, drainage, or other land reclamation; value of electric power; value of water supply for domestic, municipal, industrial, and stock-watering purposes; savings in costs of water treatment through control of pollution; and any other primary annual benefit measurable in dollars.

12(d)(2) Secondary: contributions to regional or national development, and any other secondary annual benefit measurable in dollars.

12(e) To the extent not measurable in dollars, such Statement shall include appraisals on a judgment basis of:

12(e)(1) Disadvantages: loss of fish and wildlife values; loss of scenic, recreational, and historical values; and any other loss to the Nation's resource base or other disadvantage not measurable in dollars.

12(e)(2) Advantages: increase in fish and wildlife values; increase in scenic, recreational, and historical values; increase in the value and useful life of reservoirs through reduction of siltation; and any other contribution to the preservation of the Nation's resource base or other advantage not measurable in dollars.

12(f) Each such disadvantage or advantage shall be described in detail and classified in accordance with standards of importance to be prescribed by the Board. No Commission shall submit a request for authorization of any project or activity if, within the meaning of the terms as used in this section, the total of the estimated annual costs exceeds the total of the estimated annual benefits unless such request be accompanied by such Commission's categorical and detailed finding that the advantages so far outweigh the disadvantages as to warrant authorization.

Sec. 13—Appropriations

[Provides for the preparation and submission to the Board of Review by each Basin Commission of an Annual Resource Budget for the Board's adjustment and consolidation of such Budgets into a National Resource Budget. It explicitly requires that the annual requests for funds for federal resource development activities be submitted as a unit and so considered by Congress.]

Sec. 14—Reimbursement

14(a) In order to facilitate reimbursement through direct charges where prac-

quired for each of the first six years, such expenditures to be subdivided to show the amounts allocated to each purpose referred to in Section 2 of this Act and to show the allotment of such amounts among the affected federal agencies; and

10(c)(6)(ii) the Commission's estimate of the reimbursement to be returned to the United States during each of the first six years, such reimbursement to be subdivided to show the amounts attributed to each purpose referred to in Section 2 of this Act and the allotment of such amounts among the affected federal agencies.

10(d) The Board shall prepare a consolidation of such Advance Programs in the form of a National Twenty-Year Advance Program and shall furnish a copy of such National Program and of each Commission's Advance Program to each Commission, to each federal agency concerned, and to the President for transmission to the Congress. A summary of such National Program shall be published in a manner to permit ready understanding and evaluation by the public.

Sec. 11—Authorizations

11(a) From and after ...., 195.., no proposal for or respecting any new examination, investigation, survey, study, plan, design, project, activity, program, budget estimate, or request for funds for or incidental to resource development shall be deemed authorized, or be submitted to the Congress by any federal agency, except in conformity with the provisions of this Act.

11(b) Each Commission shall, in June of each year and as provided for in Section 9 of this Act, submit through the Board a request for authorization of the prosecution of such additional projects and activities relating to resource development within its territorial jurisdiction as in its judgment may be effectively undertaken in harmony with the provisions of this Act during the six years beginning the first day of July of the year following; a request for authorization may be similarly submitted at such other times as the Commission deems warranted by exceptional circumstances.

11(c) Prior to submission of a request for authorization, each Commission may hold hearings thereon at such times and places and take such testimony as it deems appropriate. Upon timely request of any state lying wholly or in part within the territorial jurisdiction of such Commission, or upon timely request of any affected federal agency, such Commission shall hold such a hearing to provide full opportunity for oral and written presentation of views on such request for authorization.

11(d) Whether or not such a hearing is held, any state lying wholly or in part within the territorial jurisdiction of a Commission or any affected federal agency may file with such Commission a written statement of its views on a request for authorization.

11(e)–(f) [Detail special handling of requests for authorizations including agricultural production objectives and contents of reports accompanying all authorization requests.]

Sec. 12—Evaluation

12(a) Each request by a Commission for authorization pursuant to Section 11 of this Act shall be accompanied by an evaluation set forth on a standard form of Investment Appraisal Statement. The Board is authorized and directed, in cooperation with the several Commissions, to develop and prescribe, and within its discretion to revise, uniform standards and methods for evaluation and a standard form of Investment Appraisal Statement. Each evaluation by a Commission and each report thereon by the Board shall conform to such standards and methods and shall be set forth on such Statement.

12(b) *Investment Costs:* Such Statement shall include dollar estimates of the following investment costs:

12(b)(1) Direct: examinations, investigations, surveys, studies, designs, and plans; land acquisition, rights-of-way, and utility replacement; construction; administration and overhead; use of money; and any other direct investment cost measurable in dollars.

12(b)(2) Indirect: displacement or relocation of population; loss of land and minerals; and any other indirect investment cost measurable in dollars.

12(c) Annual Costs: Such Statement shall include dollar estimates of annual costs on the basis of amortization of the total direct and indirect investment costs within 50 years, with interest at the current federal long-term borrowing rate. Such annual costs shall include: operation and maintenance, including administration, overhead, and payments to states and local governments; replacements; interest and amortization; increase in the annual cost of maintaining and operating existing public services; and any other annual cost measurable in dollars.

12(d) Annual Benefits: Such Statement shall include dollar estimates of the following annual benefits:

12(d)(1) Primary: increase in net income from land made possible by conservation treatment of watershed lands; reduction in flood damage and increase in net income from property made possible by flood control; savings in transportation costs on existing traffic by waterways as compared with movement by alternative means, and similar savings in cost of moving new traffic made possible by navigation improvements; increase in net income from additional production of farm products made possible by irrigation, drainage, or other land reclamation; value of electric power; value of water supply for domestic, municipal, industrial, and stock-watering purposes; savings in costs of water treatment through control of pollution; and any other primary annual benefit measurable in dollars.

12(d)(2) Secondary: contributions to regional or national development, and any other secondary annual benefit measurable in dollars.

12(e) To the extent not measurable in dollars, such Statement shall include appraisals on a judgment basis of:

12(e)(1) Disadvantages: loss of fish and wildlife values; loss of scenic, recreational, and historical values; and any other loss to the Nation's resource base or other disadvantage not measurable in dollars.

12(e)(2) Advantages: increase in fish and wildlife values; increase in scenic, recreational, and historical values; increase in the value and useful life of reservoirs through reduction of siltation; and any other contribution to the preservation of the Nation's resource base or other advantage not measurable in dollars.

12(f) Each such disadvantage or advantage shall be described in detail and classified in accordance with standards of importance to be prescribed by the Board. No Commission shall submit a request for authorization of any project or activity if, within the meaning of the terms as used in this section, the total of the estimated annual costs exceeds the total of the estimated annual benefits unless such request be accompanied by such Commission's categorical and detailed finding that the advantages so far outweigh the disadvantages as to warrant authorization.

Sec. 13—Appropriations

[Provides for the preparation and submission to the Board of Review by each Basin Commission of an Annual Resource Budget for the Board's adjustment and consolidation of such Budgets into a National Resource Budget. It explicitly requires that the annual requests for funds for federal resource development activities be submitted as a unit and so considered by Congress.]

Sec. 14—Reimbursement

14(a) In order to facilitate reimbursement through direct charges where prac-

ticable and otherwise through the cooperation of states and local governments, each request for authorization submitted in accordance with the provisions of Section 11 of this Act shall include specific plans and provisions designed to assure maximum reimbursement, not in excess of cost, in accordance with the following general principles and consistently with the classification of purposes provided for in Section 2 of this Act and with the classification of benefits provided for in Section 12 of this Act:

14(a)(1) so far as possible, costs allocated to purposes producing primary benefits shall, to the extent of such benefits, be reimbursed through direct charges to beneficiaries;

14(a)(2) remaining costs allocated to purposes producing primary benefits shall, to the extent of such benefits, be reimbursed through agreements with states or local governments;

14(a)(3) costs allocated to purposes producing secondary regional benefits shall, to the extent of such benefits, be reimbursed through agreements with states or local governments; and

14(a)(4) all other costs, including costs allocated to purposes producing advantages not measurable in dollars, shall be borne by the United States.

14(b) The following provisions shall, on the basis of an allocation of costs made by the Commission, govern reimbursement as to each project or activity or part thereof authorized pursuant to this Act:

14(b)(1) Conservation Treatment of Watershed Lands: At such times as in the judgment of the Commission will best protect the proposed federal investment in conservation treatment of watershed lands, the head of the federal agency responsible for the conservation-treatment function shall execute one or more repayment contracts with one or more organizations representing the primary beneficiaries, and such contracts shall provide for payment of an annual amount sufficient to cover: that part of the annual operation and maintenance costs allocated to conservation treatment; the cost of replacements allocated to conservation treatment; and repayment without interest, for a period of not to exceed 50 years beginning the first year after the initiation of such conservation treatment, of so much of the capital investment allocated to conservation treatment as such agency head shall annually determine after consideration of the ability of such beneficiaries to pay in relation to their net income derived from the project or activity during the prior year and to current agricultural production and marketing conditions. Beyond such period not to exceed 50 years, payments shall be limited to that part of annual operation and maintenance costs allocated to conservation treatment and the cost of replacements allocated to conservation treatment.

An agreement shall be similarly executed with one or more states or local governments which shall provide for repayment, without interest and within not to exceed 50 years, of an amount equivalent to the secondary regional benefits resulting from conservation treatment which it is estimated will be produced by the project or activity.

All remaining conservation-treatment costs shall be borne by the United States.

14(b)(2) Flood Control: At such time as in the judgment of the Commission will best protect the proposed federal flood-control investment, agreements shall be executed with one or more states or local governments which shall provide for payments sufficient to cover: that part of the annual operation and maintenance costs allocated to flood control; the cost of replacements allocated to flood control; and repayment, without interest and within not to exceed 50 years, of the capital investment allocated to flood control to an extent corresponding with the production of primary benefits and secondary regional benefits.

All remaining flood-control costs shall be borne by the United States.

14(b)(3) Navigation: The Commission and the Board shall recommend the

nature and extent of any local contribution to be required as a condition precedent to undertaking the project or activity involved, to reimburse the United States for any navigation benefits conferred specially upon local interests. Except to the extent that the Congress may prescribe such conditions, all navigation costs shall be borne by the United States until and unless the Congress shall prescribe a general reimbursement standard after further consideration of charges for transportation by all means, including transportation by water.

14(b)(4)(i) irrigation: At such time as in the judgment of the Commission will best protect the proposed federal irrigation investment, and except to the extent that provision is made for recovery of costs by water-service contracts made pursuant to this Subsection (b)(4), the head of the federal agency responsible for the irrigation function shall execute one or more contracts with one or more organizations representing the primary beneficiaries, and such contracts shall provide for payment of an annual amount sufficient to cover: that part of the annual operation and maintenance costs allocated to irrigation; the cost of replacements allocated to irrigation; and repayment without interest, for a period of not to exceed 50 years from the date of delivery of water for an irrigation block, of so much of the capital investment allocated to irrigation as such agency head shall annually determine after consideration of the ability of such beneficiaries to pay in relation to their net income derived from the project or activity during the prior year and to current agricultural production and marketing conditions. Beyond such period not to exceed 50 years, payments shall be limited to that part of the annual operation and maintenance costs allocated to irrigation and the cost of replacements allocated to irrigation.

An agreement shall be similarly executed with one or more states or local governments which shall provide for repayment, without interest and within not to exceed 50 years, of an amount equivalent to the secondary regional benefits resulting from irrigation which it is estimated will be produced by the project or activity.

14(b)(4)(ii) if in the judgment of the Commission the federal irrigation investment will not be jeopardized thereby, the head of the federal agency responsible for the irrigation function may enter into water-service contracts for short or long terms, which contracts shall provide for payment in advance of an annual amount sufficient to cover: an appropriate share of that part of the annual operation and maintenance costs allocated to irrigation; an appropriate share of the cost of replacements allocated to irrigation; and repayment without interest of so much of the capital investment allocated to irrigation as such agency head shall annually determine after consideration of the ability of such beneficiaries to pay in relation to their net income derived from the project or activity during the prior year and to current agricultural production and marketing conditions: *Provided, however,* That the cost of any irrigation water distribution works constructed by the United States shall be separately covered by repayment contracts as provided for in Subsection (b)(4)(i) of this section: and *Provided further,* That an agreement shall have been executed with one or more states or local governments which shall provide for payment, without interest and within not to exceed 50 years, of an amount equivalent to the secondary regional benefits resulting from irrigation which it is estimated will be produced by such project or activity. Such water-service contracts shall include a right of renewal.

14(b)(4)(iii) in addition to any of the contracts provided for in this Subsection (b)(4), the head of the federal agency responsible for the irrigation function is authorized to enter into a water-service contract for short or long terms with any individual primary beneficiary to provide water for the irrigation of land held by such beneficiary in excess of any

acreage limitation under existing law at rates sufficient to cover: an appropriate share of the annual operation and maintenance costs allocated to irrigation; an appropriate share of the cost of replacements allocated to irrigation, amortization of an appropriate share of the capital investment allocated to irrigation within not to exceed 50 years from the date of delivery of water; and interest on an appropriate share of the unamortized portion of such investment at the current federal long-term borrowing rate: *Provided, however,* That the cost of any irrigation water distribution works constructed by the United States shall be separately covered by repayment contracts, as provided for in Subsection (b)(4)(i) of this section. Each such water-service contract shall include a right of renewal.

14(b)(4)(iv) With respect to each irrigation project, division of a project, or activity to which the standards of this Subsection (b)(4) shall apply, and at such time as in the judgment of the Commission will best protect the federal irrigation investment, one or more agreements shall be executed by the head of the federal agency responsible for the irrigation function with one or more organizations representing the primary beneficiaries, or states, or local governments whereby one or more of them shall guarantee reimbursement to the United States of the value, as determined by such agency head, of the use of any project waters which recharge ground water supplies to the benefit of users who do not agree to reimburse the United States for such benefit.

14(b)(4)(v) All irrigation costs not covered as provided for in this Subsection (b)(4) shall be borne by the United States.

14(b)(5) Drainage: At such time as in the judgment of the Commission will best protect the proposed federal drainage investment, one or more repayment contracts shall be executed with one or more organizations representing the primary beneficiaries, or states, or local governments, which shall include repayment standards conforming respectively with those prescribed in Subsection (b)(4)(i) of this section, except that payments shall extend over periods of not to exceed 50 years from the date of completion of construction.

All remaining drainage costs shall be borne by the United States.

14(b)(6) Power: Rates charged shall be sufficient to cover: that part of the annual operation and maintenance costs allocated to power; the cost of replacements allocated to power; payments to states and local governments in an amount equal to taxes which would have been payable on acquired property if the project had not been built, such amount to be computed at the tax rate at the time of acquisition and to be limited to so much of the acquired property as the Commission shall allocate to power; amortization of the capital investment allocated to power within not to exceed 50 years; and interest on the unamortized portion of such investment at the current federal long-term borrowing rate.

14(b)(7) Water Supply Other Than for Irrigation: Reimbursement of cost allocated to furnishing of water for purposes other than irrigation shall be accomplished in accordance with the standard prescribed in Subsection (b)(6) of this section, and contracts shall include a right of renewal.

14(b)(8) Pollution Control: At such time as in the judgment of the Commission will best protect the proposed federal investment in pollution control, an agreement shall be executed with one or more states, local governments, or industrial firms, which agreement shall provide for payments sufficient to cover: that part of the annual operation and maintenance costs allocated to pollution control; repayment within not to exceed 50 years of the capital investment allocated to pollution control to an extent corresponding with the production of primary benefits and secondary regional benefits; and interest on a corresponding share of the unamor-

tized portion at the current federal long-term borrowing rate.

All remaining pollution-control costs shall be borne by the United States.

14(b)(9) Recreation and Fish and Wildlife: All cost allocated to recreation and preservation and enhancement of fish and wildlife resources shall be borne by the United States except to the extent of provision for fees and except where provision is made for recreational facilities of primarily local significance the cost of which shall be borne by the local interests benefiting.

14(b)(10) Other Costs: Any other costs shall be provided for consistently with the general principles set forth in Subsection (a) of this section.

14(c) [Authorizes necessary and appropriate rules.]

Sec. 15—Disposition of Proceeds

All monies received by any federal agency from or incidental to the operation of any project or activity or part thereof authorized pursuant to the provisions of this Act shall be transferred to and covered into the General Treasury as "miscellaneous receipts": *Provided, however,* That such part of revenues as are collected to cover payments to states and local governments in accordance with the provisions of Section 14(b) of this Act shall be payable to such states and local governments after the end of each fiscal year by the Secretary of the Treasury upon certification of the head of the federal agency collecting such revenues.

Sec. 16—Accounting

[Requires the Board of Review to establish uniform accounting for all federal activities in the water resource field. It requires that the accounts of each Commission reflect comprehensively all federal expenditures and reimbursements, and that the Board establish and maintain a consolidation of such accounts reflecting the status of federal investment in resource development.]

Sec. 17—Water Supply and Use

In order to aid in carrying out the provisions of this Act and to assist the Congress in its consideration of legislation supplementary to this Act, the Secretary of the Interior is authorized and directed, acting through the United States Geological Survey, to compile and analyze data on the total supply of water available in the United States on an annual basis to serve existing and potential demands for and actual use of water for domestic, municipal, industrial, agricultural, and other consumptive purposes. Such data on annual supply and use shall be subdivided according to the territorial jurisdictions of the several Commissions and further subdivided within each such jurisdiction as each Commission shall determine to be most useful in the execution of its functions under this Act. Once each year beginning in 195.., the Secretary shall prepare an annual report on such data for the preceding year together with his forecasts of probable supply and use for each of the ensuing twenty years. Copies of such report shall be furnished to each Commission, the Board, each federal agency concerned, and the Congress.

Sec. 18—Structures and Obstructions

[Provides that no obstructions or structures affecting the interests of interstate and foreign commerce shall be placed across, along, or in any of the waters over which Congress has jurisdiction without the consent of the Commission concerned.]

Sec. 19—Existing Law

[Provides for the relationship of this Act to existing law.]

Sec. 20 & 21—Liberal Construction & Separability

[Contains the usual provisions for liberal construction and for the separability of provisions where any single provision is held involved.]

Study of the Arkansas-White-Red River Basins

By Louis W. Prentiss

A paper presented on Oct. 15, 1951, at the Southwest Section Meeting, Fort Worth, Tex., by Louis W. Prentiss, Colonel, Corps of Engineers; Chairman, Arkansas-White-Red Basins Inter-Agency Committee, Tulsa, Okla. The description implements the foregoing discussion of national water policy legislation in providing a picture of a river basin program at the peak of activity now authorized by Congress.

A STUDY of all phases of soil and water development is under way in the Arkansas, the Red, and the White River basins. This study is unique in two ways: it is the broadest study that Congress has yet authorized, and it marks the first time that an interagency committee has had the responsibility, from the start, of an examination and survey for the preparation of a comprehensive plan for river basin development.

There have been many previous studies of soil and water problems by the agencies with primary interests in these problems. The Corps of Engineers has made many studies for flood control and allied purposes within these three river basins, and it is building and has built several projects that serve not only the primary purpose of flood control, but also water conservation, fish and wildlife protection, pollution abatement, and other purposes. Two other construction agencies in the soil and water field, the Dept. of Agriculture and the Dept. of Interior, have also made studies, constructed projects, and initiated programs.

Under former survey procedures, the individual agencies, in the course of their studies, called upon other agencies for information and, upon completion of a report, submitted it to the interested states and agencies for comment before forwarding it to Congress. There is an essential difference between that procedure and the interagency procedure being followed in the Arkansas-White-Red River study. From the very beginning, each state and each agency has participated in the study as it developed and has had every opportunity to see that its ideas are given full recognition.

Flood Control Act

The Flood Control Act of 1950 directed the Chief of Engineers to make a study of the three basins with a view to developing a comprehensive, integrated plan of improvement for seventeen specific purposes: flood control, drainage, runoff and waterflow retardation, navigation, domestic water supply, municipal water supply, reclamation, irrigation, development of hydroelectric power, utilization of hydroelectric power, conservation of soil resources, conservation of forest resources, conservation of fish and wildlife resources, recreation, salinity control, sediment control, and pollution abatement. It is not to be assumed that

some of these purposes are incidental to others. Each bears the weight of its own importance to the people of the basins and to the nation.

The act directed that there be coordination with the Dept. of Interior, the Dept. of Agriculture, the Federal Power Commission, and other appropriate federal agencies, and with the states. The President, by a letter dated May 19, 1950, to the secretaries of the interested federal departments, requested that the coordination contemplated by the act be accomplished through the establishment of an interagency committee. He also stated that he considered it desirable, because of the language of the act, that the Dept. of the Army be designated as the chairman agency. He indicated that he considered it essential that the federal agencies draw fully upon the experience and ideas of the people of the area and that the final report carry the concurrence or comments of each affected state. As will be shown, not only the letter, but the spirit, of these instructions has been carried out.

The Federal Inter-Agency River Basin Committee in Washington, by resolution in June 1950, established the Arkansas-White-Red Basins Inter-Agency Committee, and the committee's first meeting was held in Oklahoma City on July 28, 1950. Two other field interagency committees, one in the Missouri basin, the other in the Columbia basin, had been in operation for several years; however, the functions of both are largely to coordinate and administer plans of development drawn up, to some extent, by individual agencies.

Geography and Topography

Before the organization and operation of the Arkansas-White-Red Basins Inter-Agency Committee is discussed, the geography and topography of the three-basin area should be described briefly. The territory with which this committee is concerned covers an area of 180,000,000 acres that stretches from the Mississippi River to the Continental Divide (Fig. 1). The Arkansas River flows 1,450 miles from its headwaters in central Colorado through southern Kansas, northeastern Oklahoma, and across Arkansas to empty into the Mississippi River. Its drainage area includes southeastern Colorado, northeastern New Mexico, the northern portion of the Texas Panhandle, southern Kansas, a large portion of Oklahoma, central Arkansas, and a small area of southwestern Missouri. The extreme western part of the Red River watershed reaches into eastern New Mexico. It flows for a thousand miles through the Texas Panhandle and portions of both Oklahoma and Texas where it forms a state line and drains southern Arkansas and northern Louisiana. The 700-mile White River, rising in northwestern Arkansas, flows into Missouri and back down through Arkansas to join the Mississippi at about the same point as does the Arkansas River. Including its major tributary, the Black River, the White River drains a considerable portion of southern Missouri and northern Arkansas.

The wide expanse of this territory includes varied types of terrain. In the high, mountainous western portions there are the clear, rushing, snow-fed streams. These streams converge to reach across the semiarid plains where flows frequently are intermittent; then they become the sluggish rivers characteristic of the alluvial valleys. There is heavy rainfall in the semitropical climates around the mouth of the Red

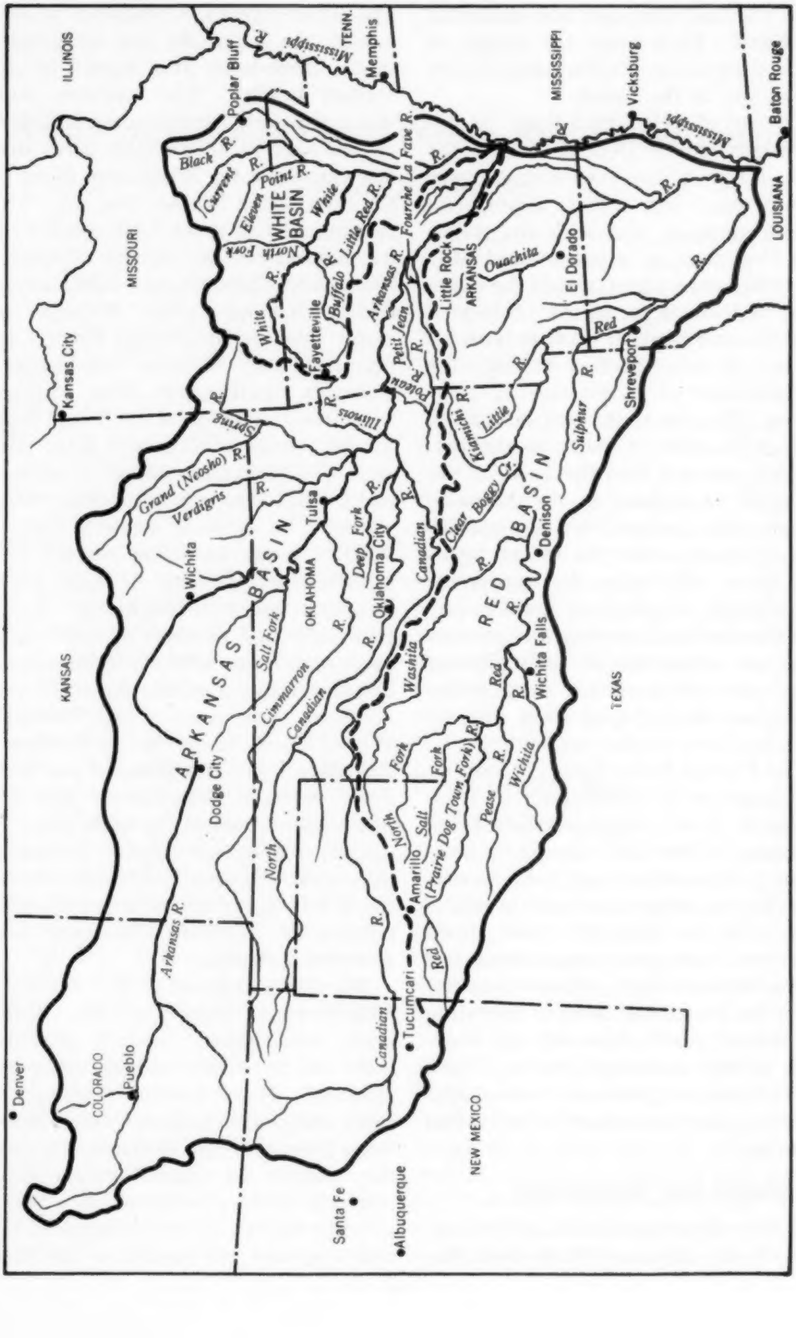


Fig. 1. Territory Covered by Arkansas, Red, and White River Basins

River, averaging considerably more than 50 in. per yr. A marked scarcity of precipitation characterizes the semiarid plains of the western part of the territory where there is less than 10 in. of annual rainfall. The annual rate of evaporation, always an important factor in planning water projects, varies, generally from east to west, from 55 in. to approximately 114 in. Soil types and vegetable growth also vary widely throughout the basins.

Mineral resources are a valuable asset to the area. There are large deposits of coal, particularly in Colorado. Large quantities of oil and natural gas are found in Kansas, Texas, Oklahoma, Arkansas, and Louisiana. Approximately 90 per cent of this country's known bauxite reserves are in Arkansas. Lead and zinc are found in Missouri, Kansas, Oklahoma, and Arkansas. Deposits of many other minerals are scattered across the three watersheds.

Economy and Population

At present, the area is predominately agricultural, with major areas devoted largely to livestock, although, in a recent study made for the interagency committee, the Dept. of Commerce found that, during the past ten years, the three basins had one of the most marked trends toward urbanization in the United States. From 1940 to 1950, the number of people living in the cities and towns increased by more than 700,000 persons, or by almost 30 per cent. At the same time, the rural population lost 775,000 persons, or a little more than 16 per cent. Nationally, the rural population increased 7 per cent. Some of the planning problems facing the committee are indicated by these facts and by the Dept. of Commerce forecast of an increase of more than 900,000 persons by 1975.

The 7,200,000 people who made their homes in these basins in 1950 represented less than 5 per cent of the country's population, although the three basins include approximately 9 per cent of its total area. The future of these people and the development of their area are tied closely to the use which can be made of the basic natural resources. Most of the problems of soil and water development follow watershed lines, but trade areas so often overlap that many people outside the geographic boundaries have an immediate, though not direct, interest in the planning for the Arkansas-White-Red River basins.

Committee Work and Organization

In carrying out its mission of preparing a comprehensive plan for development of the soil and water resources of the three-basin area, the committee must plan, not only for better use of these resources for today's conditions, but also for the needs of the reasonably foreseeable future. The states must outline the general type of economy toward which they are working under the master planning carried on by their own organizations. If some locality is thinking in terms of an industrial growth, the possibilities of planning to enhance such a growth will be thoroughly examined by the committee. If agricultural expansion and stabilization have favorable prospects, the committee's planning will explore the possibilities in that direction. The potentials in water and soil development will be determined, but guidance from the states will be expected in decisions affecting the future course of their development.

The committee is composed of representatives of the Dept. of Defense; the Dept. of Agriculture; the Dept. of In-

terior; the Dept. of Commerce; the Federal Power Commission; the Federal Security Agency; and the governors of Louisiana, Missouri, Arkansas, Texas, Kansas, Colorado, Oklahoma, and New Mexico. In all, 26 federal agencies are represented by the six federal members. Each governor has designated a representative to act for him in his absence and this official, in turn, represents the interested state agencies.

It is the committee's job to plan efficiently and thoroughly. Duplication must be eliminated, and conflicting purposes must be resolved. The skills of the experts in the various organizations will be utilized throughout the study. It is recognized, however, that this is not only a technical task but one involving the broadest concepts of economic development.

The job is big. Policy decisions are made by the fourteen interagency members. Unlike a legislative group which lays down only guides for the execution of work, the committee must supervise planning. There is not enough time for the committee itself to take up, discuss, and come to a decision on the countless problems that arise in studying every phase of soil and water development in the basins; hence organization was the first problem.

At the first meeting, the organization for the early part of the work was perfected. All pertinent basic data available to each state and agency were indexed to avoid duplication in obtaining the information necessary to carry on the study. The same general procedure was followed with maps. A central map file and a central library were established in Tulsa for those items requiring frequent reference by the forces there. A subcommittee of expert engineers representing each state and federal agency was established to determine the quantity and quality of water at state lines or other critical points.

The practice of holding technical conferences between regular meetings was adopted to assure the solution of all technical problems. A series of seventeen public hearings were scheduled throughout the basins to give every state, group, and individual an opportunity to express opinions on the nature of the ultimate goal.

By the end of 1950, the public hearings had been completed. The views expressed in these hearings were condensed into a check list that will always be ready and available throughout the planning work.

The states outlined their needs. They have, and will continue to describe these needs in greater detail.

Also in 1950, a general inventory of resources as a basis for further investigation was completed. A coordinated budget was worked out, making certain that no activities overlapped.

Work Groups and Plans

Early in 1951, work groups were organized to carry on from the point reached in the early stages of the work. These groups were formed on a functional basis—a work group for each of the various functions. The states have membership on all groups, and the federal agencies are represented wherever they have an interest in the function, the agency with the primary interest having chairmanship. Integration of purposes was thus assured at the working level as well as at the policy level.

To insure cross-coordination—that is, coordination between functional work groups—the governors' representatives were given the responsibility of ascertaining that the proper interrelation of functions was maintained on problems in their respective states.

Each work group formally outlined the procedures to be followed in the accomplishment if its task. After that operation came the adjustment of the phasing of activities of the individual work groups so that the work of each would key in with the others. It is of no value—in fact it would be detrimental—for one group to work ahead of the other groups.

By the end of June 1951, the analysis of the resources and economic development of the area had been largely completed, bringing the survey to the next phase—that is, the investigation of present and potential problems. This phase was scheduled for completion by the end of 1951.

With the nature of the problems determined, the committee will be able to start working out possible solutions for them. This activity will not merely provide one solution for each problem, but will evaluate all of the more feasible solutions that should be considered. The effects of the possible solutions on other purposes will be an important aspect and will be systematically studied late in 1952.

A considerable part of 1953 will be devoted to blocking out an overall plan, allocating costs, and determining the extent of local cooperation required. The results of the studies will then be evaluated and another series of hearings will be held to get the public's reaction to the committee's proposals. New information will be applied in selecting a recommended plan.

By that time and before plunging into the final 6-month phase of the study, the committee will stop and take stock of what has been accomplished. It will, of course, have been kept thoroughly informed, through work-group reports, of the work accomplished in each phase and will have determined the important policy matters that will serve as guides for these groups. At that point, however, a new reading will be taken to see that all work accomplished is consistent throughout with the established policies. The members themselves, as the responsible agents, will make sure that the work of all technicians and specialists gives full consideration to the desires of the people as expressed in the public hearings. The ground rules for the final completion of the work will then be laid down. Finally, the report will be written, reviewed, and revised. Revisions are to be completed by June 30, 1954, when the report is to be ready for final transmission.

Disclosures

A few facts on domestic and industrial water supply found by the Federal Security Agency in this study may be of special interest: Approximately 1,000 communities in the basins utilize public water systems which provide more than 400 mgd to approximately 3,500,000 people. In the western portion, where the precipitation averages less than one-half that in the eastern portion, the per capita use of water was more than twice that of the eastern portion. Some of the western cities average more than 250 gpcd, and most cities average at least 100 gpcd. Average consumption in all eastern cities was 50–100 gpcd. Per capita use in the basins generally increases with increasing population in cities up to the 50,000–100,000 class, and then it shows a tendency to drop off. Approximately four times as many communities use underground sources as use surface supplies. More large systems, however, use surface sources, so that approximately the same total amount is taken from each source.

A complete survey of the industrial uses of water in the basins was not

feasible, but a relatively complete picture was obtained. Reports were made covering 426 industrial plants, which used 730 mgd, or 1$\frac{3}{4}$ times as much as the municipal users. A majority of the plants utilized underground sources. As with municipal water consumption, industrial use tends to be greater where the supplies are more limited, although the pattern is neither as simple nor as consistent. Population, even when considering large segments of the three-basin area, apparently has little relation to industrial water use.

The Arkansas basin, with 55 per cent of the population of the three-basin area, used 86 per cent of the industrial water used in the entire area. The most abundant supplies of water in the area are in Missouri, Arkansas, and Louisiana; yet the Arkansas-White-Red River basin portions of these states, with 39 per cent of the population, account for less than 12 per cent of the total industrial water use in the area.

The White basin, taken as a unit, accounted for less than 1 per cent of the total industrial use, although it has a plentiful supply of good quality surface water and has 11 per cent of the population of the three basins.

Although the western part of Oklahoma is in a water-scarcity zone, industrial use in the state as a whole was 70 per cent of the total for the Arkansas-White-Red River area. Oklahoma is the only one of the eight states entirely within the boundaries of the three basins; it has 31 per cent of the population.

The total consumption reported for both municipal and industrial uses, from both ground and surface sources, was more than 1,250,000 acre-ft per yr. Approximately 80 times this amount is discharged by the three rivers into the Mississippi during an average year; this fact, however, gives little indication of the problems in meeting expanded water demands. As is shown, the greatest demand is widely removed from the greatest supply. The relationship between population and water demand is far from direct, particularly with industrial water.
average year; this fact, however, gives
Quality is an imporant factor; scarcity and poor quality often go together. Dependability of supply during critical periods of low stream flows and low ground water tables is extremely important. For these reasons, the most difficult phases of the study are yet to come.

Summary

Much remains to be done on the study as a whole. No plans or proposals exist at present even on subareas. Comprehensive planning cannot be carried on without pausing after each major step and relating the findings on each purpose to all the other purposes. The task is not one that produces a certain number of finished products at a certain interim date.

Although no specific projects or programs can at present be recommended, it is believed that progress has been good. A sound foundation upon which to build the plan has been laid—a foundation that depends for its support upon active state participation and a cooperative approach by all agencies involved. The Arkansas-White-Red Basins Inter-Agency Committee cannot only formulate a truly comprehensive and integrated plan for the development of the land and water resources of the three basins but, better still, can set the pattern for future river-basin developments—a pattern that will insure full consideration of the rights and desires of the people.

The Oxidation of Sulfides by Chlorine in Dilute Aqueous Solutions

By A. P. Black and James B. Goodson Jr.

A paper presented on Oct. 30, 1951, at the Florida Section Meeting, Daytona Beach, Fla., by A. P. Black, Head, Dept. of Chemistry, Univ. of Florida, Gainesville, Fla., and James B. Goodson Jr., Sheppard T. Powell, Cons. Chem. Engr., Baltimore, Md. The paper was based on a study conducted by the junior author as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

DISCREPANCIES in the literature concerning the dosages of chlorine required for sulfide removal in water treatment have indicated the need for fundamental research on the reaction between sulfides and chlorine in dilute aqueous solutions. Usually in the literature it is assumed that chlorine oxidizes the sulfide to free sulfur (1, 2) and that the dosage required is based on the stoichiometric relationships pertaining to the reaction, $Cl_2 + S^{--} = 2Cl^- + S$. Experimental evidence, however, has been cited by some authors (3) to indicate that the dosage required sometimes approximates the stoichiometric value dictated by the reaction, $4Cl_2 + S^{--} + 4H_2O = 8HCl + SO_4^{--}$.

Information concerning the reaction between very dilute sulfide solutions and chlorine is meager. Some excellent work dealing with the oxidation by hypochlorites of solutions containing 40 to 2,000 ppm of sulfide ion, however, was accomplished in 1937 by Choppin and Faulkenberry (4), who established that the only end products of the oxidation are sulfur and sulfate, the ratio depending upon such factors as relative concentrations of the original reactants, pH, temperature, standing time, and rate of addition of reactants. It was concluded that sulfur is the primary product of the oxidation, whereas sulfate results as the end product of secondary reactions.

The object of the investigation reported here was to study the oxidation from the standpoint of water works practice, keeping the variables, wherever possible, within the limits normally found in natural waters.

Experimental Procedure

The methods chosen for use in this investigation were based on the familiar chlorine demand method (5). Wide-mouth reagent bottles, of 625-ml volume, with screw-caps were altered to serve as reaction vessels. In a typical experiment, each of a series of the vessels was filled with nitrogen; 500 ml of oxygen-free, distilled water was introduced from a specially designed, calibrated pipet; and 25 ml of concentrated buffer solution was also added. The vessels were then immersed in a thermostat at the temperature selected for the experiment. A portion of standardized sodium sulfide solution, calculated to give the desired sulfide concentration, was added to each vessel from a microburet. The desired quantity of standardized chlorine water was measured in from another buret, and

the vessels were returned to the thermostat. They were withdrawn one by one at regularly spaced intervals of time. The reaction was stopped by the addition of potassium iodide (dissolved in enough acetic acid to lower the pH in the solution to a value between 3 and 4) and the residual chlorine or sulfide was determined by iodometric or iodimetric methods, respectively.

The distilled water used in the preparation of the dilute, working solutions in the reaction vessels was rendered oxygen-free by boiling, and it was cooled and stored under nitrogen. All concentrated solutions used in the preparation of these solutions were prepared from oxygen-free water, and all were stored under nitrogen. Furthermore, to insure oxygen-free working solutions in the reaction vessels, the apparatus used in their preparation was so designed that the entire operation could be carried out under nitrogen.

The concentrated buffer solutions were usually so constituted that the addition of 25 ml to 500 ml of diluting water gave a working buffer solution of a constant ionic strength of approximately 0.1 in the reaction vessels. This was accomplished by the addition of potassium chloride to some of the solutions. Where such relations could not be established, however, proper adjustments were made in the procedure for preparing the working solutions. All the concentrated buffers were designed to give working buffers of such strength that the pH would not be altered by more than 0.05 by the addition of the reactants.

Results

Since the end products of the reaction are known to be free sulfur and sulfate (4), the stoichiometric relationships involved in the overall oxidation may be represented by the two equations:

$$Cl_2 + S^{--} = 2Cl^- + S$$
$$4Cl_2 + S^{--} + 4H_2O = 8HCl + SO_4^{--}$$

In accordance with these relationships the mole ratios of chlorine to sulfide reacted for the formation of free sulfur and sulfate are 1 : 1 and 4 : 1, respectively, and the magnitude of this ratio for any particular set of experimental conditions may be taken as an indication of the extent of the overall reaction. Thus, use is made of this ratio

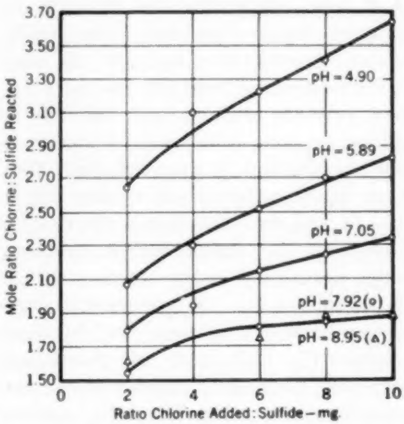


Fig. 1. Effect of Concentrations on the Ratio of Chlorine to the Sulfide Reacted

to show the progress of the reaction, and the results of the various experiments conducted during this investigation are expressed as ratios showing the moles of chlorine reacted per mole of sulfide. These ratios are frequently referred to in the following discussion as experimental ratios.

Effect of Concentrations

To determine the effect of concentrations of reactants, experiments were run at pH values varying, by unit

increments, from 5 to 9. The reaction time was held to 20 min and the temperature was maintained at 25 C. Sodium sulfide solutions containing sulfide ion equivalent to 2.0, 4.0, and 6.0 ppm hydrogen sulfide were prepared. The chlorine dosages added in each experiment were 2, 4, 6, 8, and 10 times the weight of sulfide ion present. In Fig. 1, average ratios obtained for 4- and 6-ppm solutions are plotted against ratios of chlorine added to sulfide.

The results of the experiments indicate that the sulfide concentrations employed have no effect on the extent of the reaction. The family of curves in Fig. 1 illustrates the clear-cut dependence of the experimental ratio upon pH. The curves also bring into sharp focus the effect of the ratio of chlorine added to the sulfide on the experimental ratio, and the dependence of the magnitude of this effect upon pH. The ratio of chlorine to sulfide reacted is seen to have increased in all cases with an increase in the ratio of chlorine added. This increase was quite substantial in acid solutions, but it became less marked as the pH of the medium was increased. Finally, at a pH in the neighborhood of 8, the characteristics of the increase in the experimental ratio with increased chlorine ratios appear to have become fixed and much less impressive than in acid solutions. Still another point is illustrated by Fig. 1. It may be observed that the experimental ratio is always considerably greater than unity, even when the chlorine is added on a mole to mole basis or slightly less (2.2 mg per mg of sulfide). Thus, it is shown that there is an oxidation process whereby the oxidation of a portion of the sulfide is carried beyond the free-sulfur stage while there is yet unoxidized sulfide present in the solution.

Effect of Time

Preliminary rate determinations demonstrated that there is a very rapid initial oxidation process which gives way to a much slower process. Therefore, it was decided to make the rate study in two parts, the first part dealing with the immediate reaction and the second dealing with that portion of the reaction beginning with one minute of reaction time.

For the first part of the study, buffered sulfide solutions of known concentration were titrated with standardized chlorine water under known conditions, using potassium iodide and starch as an oxidation-reduction type indicator. A study of the pertinent oxidation potentials reveals that this indicator should indicate in acid solutions when the oxidation of the sulfide to sulfur has just been completed, a conclusion that has been substantiated by experiment (6). Titrations were conducted at unit pH intervals from 5 to 9. The results indicate that the initial oxidation process proceeds only as far as free sulfur in acid solutions and somewhat beyond that stage in neutral to alkaline solutions.

The second part of the study was conducted with buffered solutions having sulfide concentrations equivalent to 4 ppm H_2S. Chlorine dosages equivalent to 4 moles of chlorine per mole of sulfide in the solutions were added quickly, and chlorine residuals were determined after 1, 5, 10, 20, 40, and 80 min. Experiments were run at pH varying by unit increments from 5 to 9, the temperature being held constant at 25 C. It was found from these experiments that the common logarithm of the experimental ratio plotted against the common logarithm of the reaction time yields a straight line. The data

are shown graphically in Fig. 2. Equations for these plots are of the type $R = at^b$, where R is the experimental ratio in mole units, t is the reaction time in minutes, and a and b are constants. Constant a indicates the extent of the reaction at the end of one minute and Constant b indicates the rate of change in the experimental ratio with time. Thus, constant b may be regarded as an empirical rate constant for the oxidation under the conditions of the experiment. The constants derived from the experiments were observed to depend quite markedly upon the conditions of the oxidation.

Effect of Temperature

Experiments identical with those employed in the second part of the rate study just described were conducted at 15 and 20 C and compared with the earlier 25 C experiments. No pattern of change in the experimental ratios attributable to temperature effect could be found. In the large majority of experiments, the maximum deviations between the ratios for the various temperatures were well within the limits of experimental error.

Effect of pH

The effect of pH on the extent of the immediate oxidation has already been pointed out. A review of the data illustrated in Fig. 2 led to the conclusion that the most satisfactory way to attack the phase of the investigation dealing with pH effect during the later stages of the oxidation would be to demonstrate its effect on the Constants a and b of the empirical equation, $R = at^b$, which was found to be applicable after one minute of time. Consequently, more experiments similar to those employed in the second part of the rate study were conducted, but at closely spaced pH intervals in the neutral range in an attempt to determine the pH at which the maximal rate indicated in Fig. 2 occurs.

In Fig. 3, Constants a (Curve 1) and b (Curve 2) are plotted against pH values. Curve 1 indicates that at a pH of slightly less than 5 the oxidation progresses almost completely to the sulfate stage during the first minute of reaction. The extent of this initial

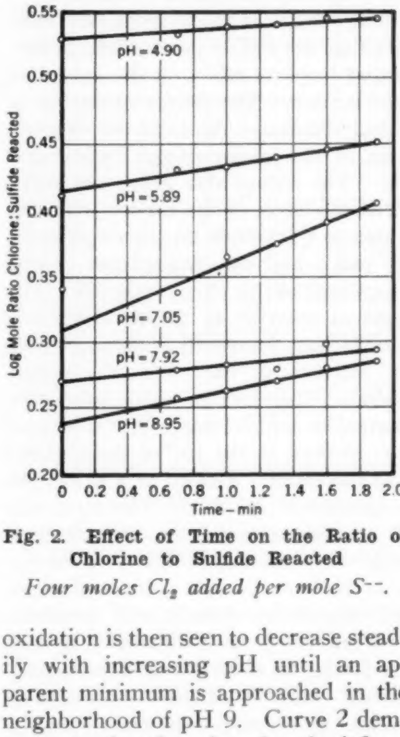


Fig. 2. Effect of Time on the Ratio of Chlorine to Sulfide Reacted

Four moles Cl_2 added per mole S^{--}.

oxidation is then seen to decrease steadily with increasing pH until an apparent minimum is approached in the neighborhood of pH 9. Curve 2 demonstrates that there is a sharply defined maximum oxidation rate that extends approximately from pH 6.5 to pH 7.3. Attention is called to the value of constant b at pH 7.92, which was disregarded in drawing Curve 2. The solutions used in that experiment had an ionic strength value twice as large as

for the solutions employed in the other experiments of the study. Later work on the effect of ionic strength justifies disregarding the above-mentioned value of Constant b in drawing the curve.

Some of the experimental data from Fig. 3 are presented in Fig. 4 in a way designed to illustrate with greater clarity some relationships not readily apparent from an examination of Fig. 3. The bumped areas in the curves of this figure result from the previously mentioned maximum oxidation rate in the vicinity of pH 7. This manner of presentation makes it apparent that in the region of the bumped area the oxidation may proceed, at a higher pH with a minimum of additional time, to the same point indicated by a considerably lower pH and a one-minute reaction time.

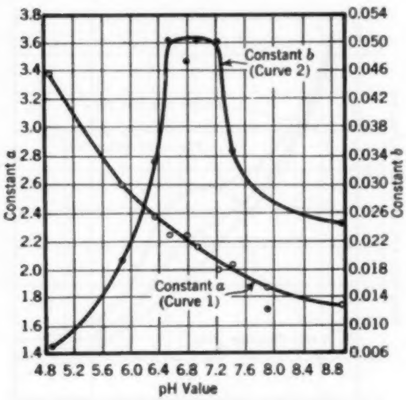


Fig. 3. Effect of pH on the Constants of the Empirical Equation $R=at^b$
Four moles Cl_2 added per mole S^{--}.

Effect of Ionic Strength

Since the rather severe pH control required during this investigation has necessitated the use of well buffered solutions, the ionic strength values of the reaction media have been many times greater than those normally encountered in natural waters. To gain further information on the reaction in solutions having ionic strength comparable with that of natural waters, experiments patterned after those used in the second part of the rate study were conducted at a pH held as nearly constant as possible at 7 over a range of ionic strength varying from 0.05 to 0.2, with the thought that the values obtained for constants a and b of the empirical equation, $R = at^b$, could be extrapolated to the desired range. The pH value of 7 was chosen for this study as the previous work had indicated little or no effect due to small changes in pH in the vicinity of this value (see plateau in Curve 2, Fig. 3). Ionic strength was varied by substituting increasing increments of a potassium chloride solution for portions of the diluting water in the reaction vessels. The results of the experiments are summarized in Fig. 5, where the values found for Constant b are plotted against ionic strength.

From Fig. 5 it appears that b has a constant value throughout the range of ionic strength from 0.05 to 0.10, and, if the extrapolation represents the true conditions, it is indicated that the oxidation rate is unaffected by variations in ionic strength in such dilute solutions as natural waters. Furthermore, it is indicated that, from the standpoint of this variable, the results of most of the experiments are applicable to very dilute solutions. It is pleasing to note that the apparent discrepancy in the value of Constant b for pH 7.92 in Curve 2 of Fig. 3 is explained by the results of this study. Whereas the other points on that curve were determined at a common ionic strength of 0.1, the point in question was determined at a

strength of 0.2. When the above-mentioned value of Constant b is adjusted by means of the curve in Fig. 5 it is brought into good agreement with Curve 2 of Fig. 3.

Effect of Chloride Concentration

In the ionic strength studies it was noticed that the initial increase in ionic strength apparently produced a definite increase in the extent of the one-minute reaction. Further increases in ionic strength failed to yield added recognizable effects. Here again it should be pointed out that potassium chloride was used to adjust ionic strength in the studies, the initial increase in strength being brought about by adding sufficient potassium chloride to raise the chloride concentration from 0 to 880 ppm. The literature (7) suggests the possibility that the observed effect on the one-minute reaction may be caused by the chloride in the salt used for ionic strength adjustment rather than by the increased ionic strength. Consequently, experiments designed to illustrate the effect of chlorides on the reaction were conducted.

These experiments were patterned after those used in studying the reaction from one minute on, with the thought that the effect could be noted in reference to Constants a and b of the equation, $R = at^b$. They were run at a constant pH of 7 and a constant ionic strength of about 0.1, while chloride concentration was varied from 0 to 1,900 ppm by substituting increasing increments of a potassium chloride solution for equal portions of concentrated buffer solution in preparing the working buffer solutions. The results of the experiments show that the full effect of the chloride concentration was apparently felt during the first minute of the reaction, since there appeared to be a definite increase in the value of Constant a with the addition of chlorides, while the value of Constant b remained the same within the limits of experimental error. It is further indicated that this increase in the extent of the one-minute reaction is stepwise with increased chloride concentration. In view of the relatively small overall change noted and the experimental error involved, however, this observation cannot be considered significant.

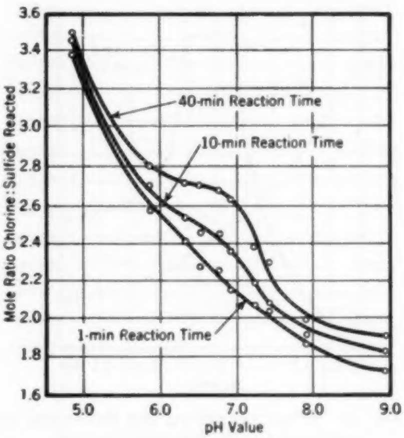


Fig. 4. Effect of pH on Ratio of Chlorine to Sulfide Reacted

Four moles Cl_2 added per mole S^{--}.

Discussion

The titrations of sulfide solutions with chlorine water offer evidence that the reaction proceeds first to the free sulfur state. It was seen, however, that, when the chlorine was added quickly, the mole ratio of chlorine to sulfide reacted was greater than unity, even when there was an excess of sulfide in the solution. This observation leads to the conclusion that there must be a process whereby a portion of the free sulfur is

oxidized simultaneously to a higher oxidation state—shown previously by other investigators to be sulfate (4). With an excess of chlorine, the oxidation was seen to progress slowly with time after the initial minute of reaction. Thus, the facts indicate that the overall reaction consists of a primary oxidation of sulfide to sulfur and a simultaneous and consecutive oxidation of a portion of the free sulfur to sulfate.

The results of the investigation show that from the standpoint of water works practice pH is by far the most important variable studied, since it exerts such a considerable influence on the dosage of chlorine required to insure

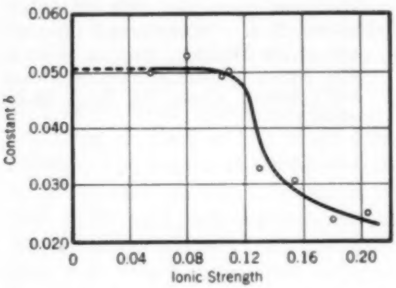


Fig. 5. Effect of Ionic Strength on the Constants of the Empirical Equation $R=at^b$

Four moles Cl_2 added per mole S^{--}.

complete sulfide removal. For example, it is estimated from Fig. 1 that about 4 mg of chlorine per mg of sulfide were required to produce a slight chlorine residual at pH 8, whereas about 7.5 mg were necessary at pH 5. This variation actually reflects the effect of pH on the secondary process that produces sulfate. Thus, it is seen that, although lower pH requires higher chlorine dosages for sulfide removal, it yields correspondingly larger sulfate to sulfur ratios in the reaction mixture. Such relationships may find possible applications where it is advisable to strike a balance between the costs of adjusting the pH, chlorination, and filtration.

It appears that the variable next in importance from the standpoint of water works operation is the effect of reaction time. Although the initial reaction by which sulfide is eliminated has been found to take place immediately upon the addition of an excess of chlorine, the secondary oxidation of sulfur has been found to progress with time. Advantage may be taken of the maximum rate of this secondary oxidation, which has been found to occur in the pH range 6.5 to 7.3. This increased reaction rate indicates that, by allowing a longer reaction time, it is possible to accomplish conveniently, at a higher pH, the same degree of oxidation in the reaction mixture that can be accomplished at a much lower pH and a shorter reaction time, using the same chlorine dosage.

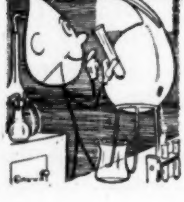
It is judged from the results of this investigation that the effects of temperature and ionic strength in the range of values normally encountered in natural waters are of little consequence.

Summary

The oxidation of dilute sulfide solutions by chlorine involves a primary oxidation of sulfide to sulfur and a simultaneous, secondary oxidation of a portion of the sulfur to sulfate. This latter reaction is also consecutive with an excess of chlorine. The primary oxidation is instantaneous in nature; however, the main portion of the overall reaction is completed within the initial minute of the reaction. Under

certain conditions the progress of the reaction from 1 through 80 min can be stated by a simple empirical equation.

The overall oxidation goes almost completely to sulfate within the first minute of reaction at a pH of slightly less than 5, but its extent decreases steadily with increasing pH until a minimum is approached at about pH 9. A broad maximum in the rate of the secondary oxidation occurs from pH 6.5 to 7.3. Sulfide concentrations in the range employed (1.90–5.65) have no effect on the overall reaction, but the ratio of chlorine added has a distinct effect, the magnitude of this effect depending upon pH. Temperature variations within the 15 and 25 C range produce no noticeable effect, and no effect is predicted from variations in ionic strength within the range found in natural waters.



References

1. Hoover, C. P. *Water Supply and Treatment.* National Lime Assn., Washington, D.C. (5th ed., 1943). p. 113.
2. Pomeroy, R. & Bowlus, F. D. Progress Report on Sulfide Control Research. Sewage Works Jour., **18**:597 (1946).
3. Powell, S. T. & von Lossberg, L. G. The Removal of Hydrogen Sulfide From Well Waters. Jour. AWWA, **40**:1277 (1948).
4. Choppin, A. R. & Faulkenberry, L. C. The Oxidation of Aqueous Sulfide Solutions by Hypochlorites. Jour. Am. Chem. Soc., **59**:2203 (1937).
5. *Standard Methods for the Examination of Water and Sewage.* Am. Public Health Assn. & Am. Water Works Assn., New York (9th ed., 1946). p. 103.
6. Bohme, H. & Schneider, E. Structure and Hydrolysis of the Sulfur Chlorides. Ber. deut. chem. Ges., **76B**:483 (1943).
7. Higgins, S. H. Experimental Investigation of the Bleaching Process: Part II. The Action of Neutral Salts on Bleaching Solution. Chem. Soc. Proc., **28**:130 (1912).

Dehumidification of Pipe Galleries at South District Filtration Plant, Chicago, Ill.

By Fred G. Gordon

A contribution to the Journal by Fred G. Gordon, Asst. City Engr., Chicago, Ill.

DEHUMIDIFICATION equipment was installed at the South District Filtration Plant to keep filter-pipe galleries dry and thus check corrosion of pipe and equipment, reduce equipment failures, cut maintenance, and improve working conditions. So far as is known, it is the first installation for this purpose in the United States. Its use in the filter galleries was preceded by a pilot installation which was placed in operation in 1948 in the West Pump Room. The results obtained with this initial equipment were so satisfactory that plans and specifications for the larger units were prepared, and a contract was awarded for their construction.

Moisture-Removal Methods

The problem is one of removing moisture from the air in sufficient volume to prevent its condensation on cool surfaces, such as concrete walls, pipes, valves, controllers, and other equipment. This aim may be accomplished either by lowering the temperature of the air or by the use of sorbents.

In the first method, the air is either passed over cooling coils or cooled with an air washer to a temperature at which the dew point is low enough to prevent condensation on cold surfaces.

In the second method, the air is brought in contact with sorbents, substances which have the property of extracting and holding water vapor. Substances used for this purpose have a capacity for moisture which, in proportion to their volume and weight, is great. The terminology employed is of interest. If the substance does not change physically or chemically during the process, it is known as an "adsorbent." Examples of adsorbents are: activated alumina, silica gel, and activated bauxites. If the substance changes physically, chemically, or in both ways during the process, it is known as an "absorbent." Calcium chloride is a solid absorbent; liquid absorbents include solutions of lithium chloride, calcium chloride, lithium bromide, and the ethylene glycols.

The second method, employing lithium chloride, is the one used at the South District Filtration Plant. The equipment consists of a dehydrating unit through which air is passed, with provision outside the unit for distribution of the dry air throughout the area served.

Plant Description

The capacity of the exhaust fan at the unit in the West Pump Room is 5,000 cfm. The dried air from the fan is discharged into a galvanized-steel duct which is suspended from the ceiling and extends the length of the pump

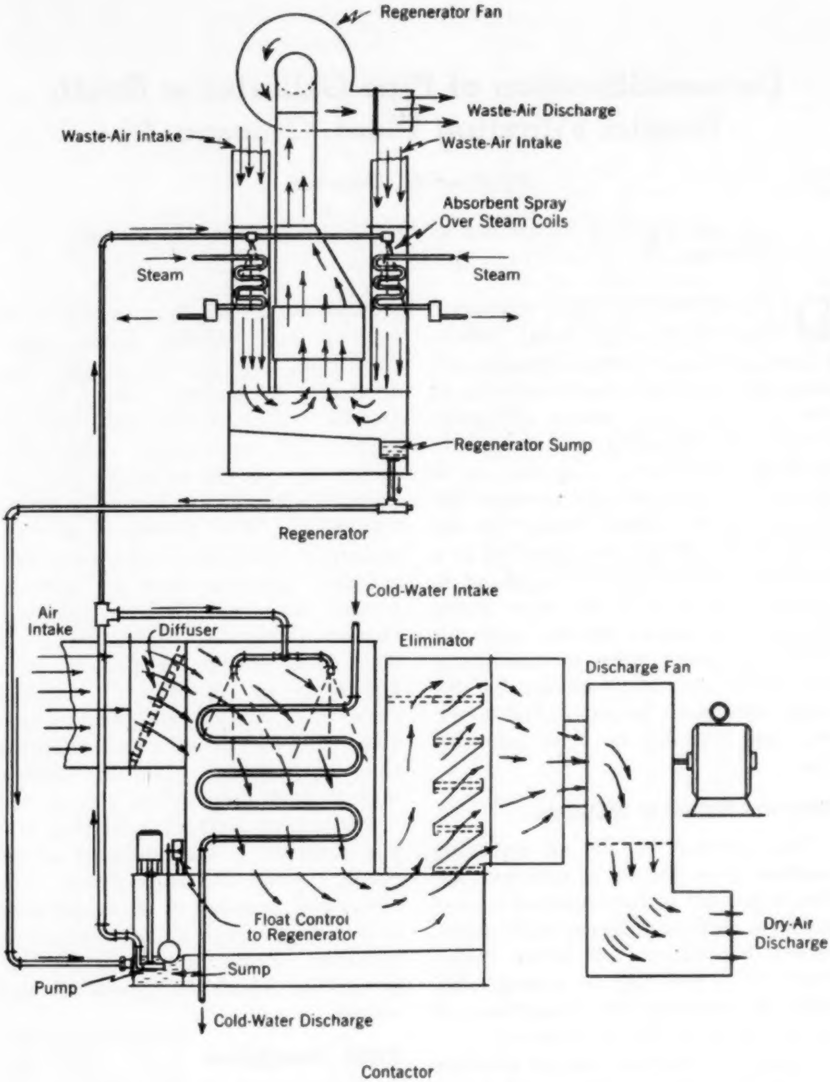


Fig. 1. Schematic Diagram of Dehumidification Units

The air washer and the regenerator are incorporated in one unit. The air-drying phase of the cycle is shown in the lower portion of the diagram; the absorbent regeneration in the upper portion.

room. Four diffusers along the length of the 210-ft duct distribute the dry air uniformly. The volume of the room is 234,000 cu ft. With no makeup air from the outside, an air change takes place every 47 min. Makeup air can be introduced from the outside through suitable damper arrangements. Such air can be used to limit infiltration and moisture penetration through walls.

A different arrangement is used for air circulation in the filter galleries, where advantage is taken of the general arrangement to provide a circuit for the dried air. The unit serving Galleries 1 and 2 is located at one end of Gallery 2. Dry air from the unit is discharged down Gallery 2, at the other end of which it enters a filter-pipe gallery and flows into and through Gallery 1. It completes the circuit by flowing through another pipe gallery and returning to the dehydrating unit. To assist in moving the air around the circuit, a booster blower of the propeller type is installed in Gallery 1. This blower is located along the center line of the gallery approximately 25 ft east of the midpoint. The fan is installed in the open gallery, and no attempt was made to insure positive circulation by inserting the fan in a diaphragm wall.

The arrangement of the unit, the air circulation, and the booster blower is similar for Galleries 3 and 4.

The main blower at each unit has a capacity of 17,500 cfm of air. The total air volume of all galleries is 1,350,000 cu ft. With no makeup air from the outside, an air change requires 39 min. Provision has been made for makeup air equivalent to 10 per cent of the fan capacity. As with the wash-water pump room, this permits maintaining a positive pressure if desired.

Equipment

Specifications for the equipment required the bidder to state in his proposal:

1. Manufacturer of the dehydrating machine.
2. Name of dehydrating material.
3. Steam required per hour at 25 psi gage when outside air contains 100 grains of moisture per pound of dry air, and air discharged from the machine contains 32 grains of moisture per pound of dry air, the amount of outside air and the main blower capacity being specified.
4. Water in gallons per minute, at 40 F, required under conditions previously stated.
5. Number and horsepower of motors.

Table 1 contains the information furnished by the successful bidders for

TABLE 1

*Data on Installations**

Item	Wash-Water-Pump Room	Filter Galleries†
Manufacturer	Surface Combustion Corp., Toledo, Ohio	Surface Combustion Corp., Toledo, Ohio
Dehydrating material	Lithium chloride	Lithium chloride
Steam—*lb per hr*	390	1,280†
(Proportion outside air—%)	50	10
Cooling water—*gpm*	42	174†
No. motors	2 at ¾ hp 1 at 3 hp	4 at 2 hp† 2 at 3 hp† 2 at 10 hp†
Capacity—*cfm*	5,000	35,000†
Amount of bid	$14,400	$38,918†
Total installation cost	$18,520	$60,473†

* The units are marketed under the trade name "Kathabar" and the lithium chloride solution used as the absorbent is called "Kathene."

† Two units.

the two installations, the amount of the bid, and the total installed cost.

The unit furnished for the wash-water pump room incorporated both the air washer and the regenerator in

one unit (Fig. 1). External utility connections furnished by the city included compressed air, steam at 25 psi, water, and power.

Each of the two installations for the filter galleries had a separate regenerator and washer unit. The washer unit is 8 ft 10 in. high and requires floor space of 10 × 7.5 ft. The regenerator unit is 6 ft 4 in. high and requires a floor space 5 ft 9 in. by 2 ft 8 in. The regenerator unit discharges waste air containing moisture driven off the lithium chloride into the dry area below the filter-gallery floor. Asbestos-cement pipe is used as a conduit for this air.

Operating Cycle

In operation, the filter-gallery units include a 10-hp supply blower, a 3-hp circulating pump for the absorbent, and a 2-hp booster blower in the gallery; these units are run continuously. The control system includes a float switch in the sump of the washer unit that starts the waste-air fan in the regenerator unit. Starting this fan, in turn, opens the steam valve. The float switch also closes the steam valve, and a thermostat in the waste-air conduit shuts down the regenerator fan. Opening and closing of the water valve is controlled by a thermostat in the sump.

The operating cycle consists of passing the air to be dehumidified through a spray of the absorbent solution. The solution is pumped continuously from the sump, a part of the discharge going to the regenerator for the removal of excess moisture. As the spray picks up moisture from the air, the liquid level in the sump rises and, at a predetermined point, operates the float switch, thus starting the regenerator fan and opening the regenerator steam valve. When heated, the solution gives up moisture which is removed by the waste-air fan. When, as a result of moisture removal, the solution in the sump has dropped to the correct level, the float switch cuts off the steam supply to the regenerator. The exhaust fan continues to run, however, until the waste-air temperature is lowered enough to be stopped by the thermostat.

One further control is provided by the cooling water. Because the absorbent's ability to remove water from the air decreases as its temperature increases, cooling water is used to maintain a constant temperature. The amount of cooling water used is regulated by a thermostat in the sump.

Power for all the motors but that in the regenerator is required continuously. Steam consumption, the amount of cooling water, and power for the regenerator motor depend on the load.

Lithium chloride solution has the advantage of being nonexplosive and nonflammable, and it cleans the air while removing moisture. Except for a slight loss due to splash and sampling, it lasts almost indefinitely.

The units are self-contained and require only occasional inspection. They are cleaned annually to guard against possible breakdown and to renew some of the solution but otherwise require very little maintenance. The savings in the cost of maintenance of instruments and filter equipment in the parts of the plant where the dehumidifying equipment is in operation as a result of eliminating most of the severely corrosive conditions, should more than pay for the cost of the dehumidifying equipment in a few years.

Discussion

Arthur Horwitz

Engineering Draftsman, South District Filtration Plant, Chicago, Ill.

The installation of dehumidification equipment at the South District Filtration Plant has successfully solved the problem of condensation in the pipe galleries. Prior to September 1950, when the dehumidification equipment was installed, the relative humidity in the pipe galleries for long periods of time was 98 per cent. A layer of condensate covered all walls, the floor, the ceiling, and all pipes and filter rate control equipment. Corrosion of the rather delicate rate control equipment was becoming a serious problem, paint peeled off metal surfaces, and maintenance work could not be performed for more than short periods of time in the cold, damp atmosphere. It was to alleviate these conditions that the dehumidification equipment was installed.

The absorbing agent used in the dehumidifiers is an aqueous solution of lithium chloride with a small amount of sodium chromate added to act as a rust inhibitor. Lithium chloride has a great affinity for water and will absorb water vapor from the atmosphere until it becomes saturated. A warm solution of lithium chloride and water will not absorb as much moisture as a cold solution. A dilute solution, of course, will not absorb as much moisture as a more concentrated solution.

It is therefore apparent that three problems present themselves before the moisture-absorbing property of lithium chloride can be utilized. First, lithium chloride solution must be introduced into the air in such a manner as to enable it to absorb a maximum amount of moisture. Second, a method must be provided to keep the temperature of the solution low. Third, there must be a means of removing the moisture from the solution at periodic intervals. The dehumidification unit described provided an adequate solution for these three problems.

Reason for Condensation

As the walls on all sides of each gallery are retaining walls for the filters, the settled water header, and the clear wells, and the settled water lateral runs along the ceiling of the gallery, the room is almost completely surrounded by water.

The water passing on the other side of these walls and within the pipes in the galleries is almost always cooler than the air temperature in the galleries. When the air in the galleries comes in contact with these cool surfaces, it is cooled almost to the temperature of the water. As it cools, its capacity to hold moisture decreases. If it cools below its dew point, it deposits some of its moisture on the cold surfaces.

The air temperature in the filter galleries prior to the installation of the dehumidification equipment varied from 70 F in summer to 35 F in the winter. At 70 F one pound of dry air can hold up to 110 grains of moisture (7,000 grains = 1 lb). At 35 F one pound of dry air can hold only 30 grains of moisture. If saturated air at 70 F touches a cold surface, for every pound of air that cools down to 35 F, 80 grains of moisture will be given up. If at least 81 grains of moisture are removed from each pound of air before

it touches the surface, however, the air can cool all the way down to 35 F without giving up any moisture.

The preceding example is, of course, very extreme, but serves to illustrate what is being done with the dehumidification equipment. The air temperature in the galleries normally runs about 2 F above the temperature of the water, so that it is necessary to remove only approximately 10 to 15 grains of moisture per pound of air to eliminate condensation.

Air which is not completely saturated tends to pick up moisture from objects which it surrounds until it approaches saturation. The air entering the dehumidifier is quite moist, with an average relative humidity of approximately 60 per cent. The air leaving the dehumidifier is very dry, with relative humidity averaging approximately 25 per cent. The dried air then passes through the galleries picking up moisture which is constantly infiltrating through the walls of the filters and clear wells, and leaking from expansion joints and pipe joints. If the air is dry enough when it leaves the unit so that it can make a complete circuit of the galleries without picking up enough moisture to raise its dew point temperature above the temperature of the water behind the walls, no condensation will take place, and the galleries will remain dry.

Fig. 1. Filter Pipe Gallery Before Dehumidification

Before dehumidifiers were installed, every surface in the gallery was covered with moisture and there was even a light mist in the air. The relative humidity was 98 per cent.

The extent to which the air must be dried will be directly proportional to the rate of infiltration and leakage of water through gallery walls and from pipe joints and other sources.

Evidence of the success of the dehumidifiers is given by the contrast between Fig. 1 and 2, which show filter pipe gallery No. 2 before and after dehumidification. Prior to the installation of the dehumidifiers, every surface in the gallery from the floor

to the ceiling was covered with moisture. The relative humidity was 98 per cent, and there was even a light mist hanging in the air when the photograph was taken.

In Fig. 2, photographed after the dehumidifiers were placed in service, wet spots may be seen on the floor, but otherwise the gallery is completely dry. The wet spots are the result of leaks from pipe joints and expansion joints in the walls and ceiling, and will be eliminated in the near future. The relative humidity at the time the photograph was taken was 50 per cent. The relative humidity has been as low as 40 per cent, and, in winter, when the expansion joints tend to open, may go as high as 70 per cent, but there will be no condensation.

Fig. 2. Filter Pipe Gallery After Dehumidification

As a result of dehumidifier operation, the gallery is almost completely dry. Wet spots on floor are the result of leaks from joints in pipes and walls. The relative humidity was 50 per cent.

Maintenance

Maintaining the dehumidification equipment is relatively simple. The units run continuously with very little danger of a breakdown. If the cooling water supply is cut off, the units will operate less efficiently, but they will continue to operate. They will also continue to run, without the steam supply, operating less and less efficiently until the solution becomes so dilute it can no longer absorb moisture. Failure of the air supply causes the cooling water valve to open wide and the steam valve to close, producing the same effect as a steam supply failure. An electric failure, would, of course, stop the unit completely, and the automatic controls would shut off both the steam and cooling water.

Only if the unit fails to end the regenerating cycle, and continues to concentrate long after it should, would it be in any danger. In that event, the pump would run dry and might burn a bearing, and the absorbent might crystallize inside the unit. An

operating engineer in the filter building makes an inspection during each shift to insure proper operation, and a daily log is kept to help observe any trends toward a failure.

The units are cleaned completely once each year. At that time all dirt which may have accumulated in the sump is removed; filters are cleaned or replaced; coils are inspected for leaks; nozzles are cleaned; pump and float assemblies are inspected for wear; and the absorbent is filtered to remove foreign matter. Care must be taken to avoid splashing and prevent skin irritation by washing any drops off immediately, and it must not be allowed to come in contact with the eyes.

The filter must be cleaned approximately once a month, and the intake air filters must be replaced when dirty—about twice a year—but no other work need be done on the units between annual cleanings. Very little absorbent is lost, normally, so that there is no need to replenish the supply unless it is desired to increase the working concentration. A sample of the solution is sent to the manufacturer each month, and is analyzed for concentration, cleanliness, alkalinity, and quantity of inhibitor. A report of this analysis is then returned, together with advice about the optimum concentration to use and the general condition of the solution.

The approximate cost of operating the two units in the filter pipe galleries is given in Table 1. The cost of compressed air is practically nothing, as the air is in a sealed system and the only addition required is to compensate for leakage. Two booster fans in Galleries 1 and 3 have 2-hp motors each, but experience has shown that they exert very little influence on conditions in the galleries, and for that reason they are not used.

TABLE 1

Cost of Operating Two Dehumidification Units

	Daily Cost
1,000 lb of steam per hr at 0.05¢ per lb	$12.00
210,000 gal. of cooling water per day at $12.50 per mil gal	$ 2.62
537 kwhr of electricity per day at 0.8¢ per kwhr	$ 4.30
TOTAL cost of operation	$18.92*

* $6,900.00 per year.

The cost of operation is small when measured against the savings in repairs to filter control equipment and piping, cost of repainting, and improved working conditions in the galleries.

Questions and Answers on Radioactivity

By R. A. Lauderdale and Eugene M. Diskant

An extract from an exchange of correspondence between R. A. Lauderdale, Associate Health Physicist, Sedgwick Lab. of San. Science, Dept. of Civ. & San. Eng., Massachusetts Inst. of Technology, Cambridge, Mass., and Eugene M. Diskant, Chemist, Dept. of Water and Power, Los Angeles, Calif.

FOLLOWING the appearance of an article on decontamination experiments in the May 1951 issue of the JOURNAL (1), Mr. Diskant asked Mr. Lauderdale several questions related to the original articles. Those questions, together with Mr. Lauderdale's answers are presented below.

1. Measurements

You refer back and forth between microcuries and counts per minute. The latter figure, of course, depends upon the overall counting efficiency under the test conditions, but that fact is not mentioned, nor is it stated how the initial activity was determined to be 2.5 microcuries per ml. In the left column of page 329, the relation among counts per minute, curies, and the definition of one curie leads to the calculation that the overall counting efficiency must have been 4.5 per cent, whereas a similar calculation applied to the data in the caption beneath Fig. 2 results in a counting efficiency figure of 8.5 per cent. Did you use a different counting arrangement? I bring this up because we in the water works industry are novices at measurement of radioactivity. In *Nucleonics,* which is addressed to the expert in the field, your terms will not confuse, but in the JOURNAL they may be misleading. Perhaps a note which states how you calibrated your instruments to obtain the overall counting efficiency and calls explicit attention to the difference between counts per minute and disintegrations per minute would be appropriate.

Answer

All of our counting was done with a standard end-window type Geiger counter. With a counter of this type, the counting efficiency is dependent on the energy of the sample radiation and will vary from 0 to approximately 10 per cent for energies between approximately 0.1 Mev and 3.5 Mev. Emmons and I have done some work on this subject, and although the data are not ready for publication, we have established that the relation between counting efficiency and particle energy may be represented by a curve, the shape and position of which will vary depending on the characteristics of the counter and on the method of sample preparation. The average energy of the sample radiation can be closely approximated by absorption measurements. By using this method we were able to determine that the counting efficiency for the influent water should be 8.5 per cent, whereas that for the effluent, which was of different composition,

should be approximately 4.5 per cent. It would have been better, perhaps, if we had converted all of our data to a common basis—either to disintegrations per minute per milliliter or to counts per minute per milliliter at 10 per cent geometry.

2. Efficiency of Steel Wool

May not the astonishing efficiency of steel wool have been due to the adsorptive properties of a film of ferric hydroxide formed upon it? Ferric hydroxide has long been used as a water coagulant and also for "collecting" radioisotopes from a large bulk of solution for assay.

Answer

It would be extremely interesting to determine whether your hypothesis concerning the efficiency of the steel wool is correct. We have conducted experiments using ferric hydroxide as a coagulant for removing radioisotopes and found that, although it was very effective with some isotopes, such as the rare earths, it was very inefficient for removing ruthenium, cesium, and strontium. For this reason we felt that the mechanism of removal must be something other than adsorption on a floc. The efficiency could be much different, however, in a column type of operation.

3. Clay

The specificity of the calcined clay is most interesting. What type of clay was it made from?

Answer

The clay used was in the form of calcined pellets, called "Multisorb," a product of the Dennison Mfg. Co., Asheville, N.C. The literature we received from the manufacturer did not identify the type of clay used. However, I have tested a kaolinitic clay found in the vicinity of Oak Ridge and a montmorillonitic clay from Mississippi and found them almost equally effective for the removal of cesium.

4. Method of Determination

As we in the water works field are interested, too, in monitoring our water supplies and the soils of our watersheds, we should be grateful to know how you determined the activity absorbed by the steel wool, burnt clay, activated carbon, cation resin, and anion resin. Did you elute the activity from the solids (if so, how), or did you measure them in the solid state and apply appropriate corrections for self-absorption (if so, how)?

Answer

The activities of the different components of the column were eluted with strong hydrochloric acid. By making a large dilution, samples could be prepared for counting and for radiochemical analysis using the standard techniques of carrier precipitation.

Reference

1. LAUDERDALE, R. A. & EMMONS, A. H. A Method for Decontaminating Small Volumes of Radioactive Water. Jour. AWWA, **43**:327 (May 1951).

Organization of Old Hickory Utility District

By H. B. Richards

A paper presented on Sept. 17, 1951, at the Kentucky-Tennessee Section Meeting, Louisville, Ky., by H. B. Richards, Chairman, Board of Commissioners, Old Hickory, Tenn.

THE village of Old Hickory was built during World War I for the personnel of a large federal government powder plant. After the war the powder plant and all of its facilities were purchased by the Nashville Industrial Corp., which immediately proceeded to dismantle and salvage the plant, making the village practically a ghost town.

In 1923 the E. I. du Pont de Nemours & Co., Inc., purchased the village proper plus sufficient acreage for a rayon plant installation. Upon completion of the plant the houses in the village were renovated and leased to the employees. All the facilities necessary for a community of six to ten thousand inhabitants were installed, maintained, and operated by the company at no cost to the citizens. Because there was only a limited number of dwellings available and because some employees wished to own their own homes, two communities have been developed adjacent to Old Hickory—Dupontonia to the north and Rayon City to the south. These communities have been growing gradually for the past twenty years.

In 1947 the du Pont Co. decided to dispose of all residential and business property in the village. After putting the buildings and facilities in first-class condition and replacing the old sewage disposal plant with a modern one, the company offered the property to its employees at reasonable prices. With the idea that it would be to the advantage of the new homeowners of this attractive, modern village to set up machinery to furnish their own public services rather than having an independent utility assume the responsibility, the company suggested this possibility to the residents.

It must be remembered that the residents of the community had been furnished water, sewage disposal, trash and garbage collection, police and fire protection, streets and roads, and street lighting at no cost to them. Their homes were kept in repair and redecorated at frequent intervals on a scheduled basis. Thus, they were unfamiliar with the responsibilities, such as maintenance, insurance, local and county taxes, that go with home ownership.

To assist them in making a decision, the citizens formed a civic organization called the Old Hickory Governmental League. The function of the league was to make a study of the various types of government and to present to the people facts and cost figures on the types they preferred. The group decided to furnish complete data on city manager-council type government and on utility district organi-

zation. The adjacent communities preferred the mayor-alderman form of government, however, and a league-sponsored opinion poll showed that a majority of the citizens was in favor of this type. Consequently, the league prepared and presented in open meetings a proposed charter for the mayor-alderman form of government.

Meanwhile, the du Pont Co. turned over the streets, sidewalks, and roads to the county, dissolved the police department, and arranged for the county sheriff to take over police protection. The citizens also began to consider a utility district in preference to the mayor-alderman form of government. To this point the company had not been approached for the selling price of the water system, sewage system and disposal plant, and fire hall and equipment. In addition, the company had the only source of water supply and had not been consulted about furnishing water to the village.

The total appraised value of the utility properties was slightly more than $800,000. When the league conferred with the du Pont Co., it found that the company's prime concern was to make the ownership of property as light a load as possible. The company agreed, that if and when a proper utility district was formed, it would sell and convey the water distribution system, the sewer system, the sewage disposal plant, the fire protection equipment, fire hall, and fire alarm system for the nominal consideration of $1.00. The company also agreed to enter into a contract to supply a maximum of 500 mil gal of water per year at a rate of $60 per mil gal. This contract will cover a fifteen-year period, but will remain in force indefinitely unless the district receives notice two years in advance of the company's desire to terminate the contract. After fifteen years the district has the right to cancel the contract upon 30 days' written notice. The Old Hickory Governmental League held another opinion poll after the du Pont Co. made its offer and found that the citizens, by an overwhelming majority, favored taking the steps necessary to establish a utility district.

The community of Old Hickory is now composed of 1,161 residential properties, a two-story brick apartment house containing 24 units, 8 churches, 29 business establishments, and 102 residential building lots which have all been purchased.

Utility District Formation

The Public Acts, 1937, Chapter 248, of the state of Tennessee give rules for establishing a utility district:

A petition for the incorporation of a utility district may be submitted to the county judge or the chairman of the county court in which the proposed district is situated. Petition to be signed by not less than 25 owners of real property residing within the boundaries of the proposed district.

Petition shall include:

1. Statement of the necessity for the service to be supplied by the proposed district.

2. Proposed name and boundaries of the district.

3. Estimate of cost of acquisition or construction.

4. Nomination of three residents of the district for appointment as commissioners.

Petition shall be signed by the petitioners with the sworn statement of person or persons circulating the petition that each signature is valid and that of a bona fide owner of real property and within the district.

County judge or chairman of the court shall then be duty bound to fix a time

and place for public hearing upon the convenience and necessity of the incorporation of the district. Such hearing shall be held not more than 30 days after the receipt of the petition and notice shall be published not more than fifteen days prior to the date of hearing in a newspaper of general circulation in the proposed district. If there is no such newspaper, notice shall be posted in five conspicuous places within the boundaries of the proposed district.

If at the public hearing the county judge or chairman finds that:

1. Public convenience and necessity requires the district's creation, and

2. That creation is economically sound and desirable, he shall enter an order of the court approving the creation of the district, defining its territorial limits, and appointing as commissioners those persons nominated in the petition, one for term of two years, one for three years, and one for four years.

All costs of publication, of posting, etc., shall be borne by the petitioners.

Appeal on the creation of the district may be made to circuit court of the county.

Districts so incorporated shall be a 'municipality' or public corporation in perpetuity *but without any power to levy or collect taxes*. It shall be the sole public corporation empowered to furnish such services in the district.

Commissioners' offices shall be filled by election of the other commissioners then in office. There shall be no compensation for service on the board. There shall be two officers, president and secretary. Only persons resident in the district may serve on the board.

District may be created for purpose of conducting or operating water, sewer, or fire protection system, or any combination of these. District may acquire, construct, reconstruct, improve, extend, consolidate, maintain, and operate such a system or systems within or without the district and may purchase from, and furnish, deliver and sell to, any municipality, the state, any public institution and the public, generally, any of the services authorized.

District has general municipal powers such as to make and enter into contracts, fix and maintain rates, issue bonds.

Board shall have power to authorize bond issues with maturity not exceeding 40 years to be payable from the revenues of the district. Bond holders shall have statutory lien on the system constructed until payment is made in full. If default is made on the payment of all interest on such bonds, court may appoint a receiver to administer such district with power to charge and collect rates sufficient to repay obligations.

Systems and bonds issued under this act shall be exempt from all state, county, and municipal taxation. The Railroad and Public Utilities Commission shall have no jurisdiction over these systems.

The utility district shall have powers of eminent domain.

The Public Acts, 1947, Chapter 76, amend these rules by authorizing utility districts to construct and operate systems for the furnishing of water, sewer, sewage disposal, police, fire protection, garbage collection and disposal, street lighting, parks, and recreational facilities.

The proposed Old Hickory district is being organized to furnish, at the present time, water, sewage disposal, street lighting, garbage and trash collection, and fire protection, with the intention of later taking over parks and recreational facilities. In establishing the organization the commissioners plan to employ a legal adviser, a district superintendent with assistance for meter reading when necessary, a bookkeeper-clerk to operate the office, and two full-time laborers for work at the disposal plant and on the mains. Any tapping and repairing of lines will be done by a plumber under contract.

Financial Plans

In establishing the district, preliminary studies indicated that it would be necessary to issue bonds to the extent of $125,000 to cover the installation of water meters, remodeling of the fire hall to furnish necessary office space, equipment for the office, setting up a bookkeeping and auditing system, and operating capital. All other costs will be covered by monthly revenue.

In order to retire the bond issue and to create a proper reserve, the following schedule of rates is being considered:

Residential

Up to 4,000 gal—$1.50
Next 6,000 gal—$0.30 per thousand
Next 20,000 gal—$0.25 per thousand
Next 30,000 gal—$0.20 per thousand
All over 60,000 gal—$0.15 per thousand

Commercial

Up to 5,000 gal—$2.00
Next 4,000 gal—$0.30 per thousand
Remainder—same as residential

Sewer charges will be based on a charge of $0.50 per month for residential property and $1.00 per month for commercial property; all establishments which have more than ten employees will pay on a sliding scale based on the average number employed. Street lighting will be furnished under contract at $0.25 per month per family. Garbage and trash collection will be under contract based on two pickups per week for residential property at $1.00 per month. The cost to commercial establishments will be based on the frequency of pickup.

The league is contemplating the establishment of a combination paid and volunteer fire department, with two paid firemen on duty at all times. The cost to each residence of maintaining a fire department will vary from $10 to $16 per year according to property value. The cost to commercial establishments will vary on the same basis as residential property. As the fire department will be the only source of fire protection for the entire community, the property owners outside the district limits will obtain protection on a subscription basis.

Well Supply Development for Memphis, Tenn.

By Justin J. Davis

A paper presented on Oct. 24, 1950, at the Kentucky-Tennessee Section Meeting, Memphis, Tenn., by Justin J. Davis, Chief Water Distribution Engr., Memphis Light, Gas, & Water Div., Memphis, Tenn.

THE population of Memphis, Tenn., has increased more than 100,000 during the past decade to reach the present total of approximately 400,000 people. The increased demands for water resulting from this rapid growth have severely taxed the water division's facilities, as the pumping plants are rapidly approaching their capacities. The water division is preparing to install a third pumping station and to develop an additional water supply which should be adequate for the next twenty years. The two existing pumping stations—Parkway, constructed in 1923 to deliver 25 mgd (1), and Sheahan, constructed in 1933 to deliver 30 mgd—are still in excellent condition, however, and have a long and useful life before them.

Geographical Background

The entire water supply of Memphis has been pumped from water-bearing sands under the city for more than 60 years. The city is located in the upper Mississippi embayment of the Gulf Coastal Plain. The accepted geological theory is that the Gulf of Mexico formerly extended to the present mouth of the Ohio River in the vicinity of Cairo, Ill. This arm of the sea stretching inland was formed by a rock trough tilting southward from the upper end at Cairo. The north and south axis of the trough passes slightly west of the present channel of the Mississippi River at Memphis. The east edge of the trough is the rock formation near the Tennessee River approximately 90 miles east of Memphis; the west lip of the formation comes to the surface west of the Black River in Arkansas, approximately 100 miles west of Memphis. The floor of the trough slopes approximately 30 to 40 ft per mile from the east lip toward the west. This slope decreases as it approaches the axis, until, as it passes under Memphis, it is almost level and then rises toward the west.

Layer upon layer of gravel, sand, and clay has been deposited in this rock valley, which is at least 2,650 ft deep. Geographically these layers or strata have been identified and named, and their outcroppings have, for the most part, been located between Memphis and the Tennessee River.

Available Water-Bearing Strata

There are at least four different and clearly separated water-bearing strata under Memphis. Each has a water with a temperature and mineral content different from any of the others and the water from each has a different hydrostatic head. Although it is possible that these strata have some connection and that waters from some

of them may find their way into others, no indication of such intermingling has been observed by the division. It is felt that the development of a supply from any stratum may be undertaken without effect on the water or hydraulic head in the other strata. The four known strata of water-bearing sand under Memphis are:

1. The shallow-well stratum which lies from 30 to 100 ft below the surface and consists of 20 to 50 or 60 ft of sand and gravel. The dissolved solids content—particularly iron—in the water from this stratum varies considerably. This water has never been used by the water division as a source of supply, but most suburban homes outside the area supplied by the division mains have small wells that tap it, and a few of the industries in the city utilize it for cooling purposes.

2. The 500-ft stratum—so-called because the division's wells average approximately 500 ft in depth—which begins from 250 to 300 ft below the surface and extends to approximately 900 ft. This stratum is separated from the first or shallow-well stratum by a 100- to 300-ft layer of impervious blue clay. Water from this stratum is almost ideal for human consumption. It is relatively soft and contains no excessive mineral content beyond 1 to 1.5 ppm of iron, which is readily removed by aeration and filtration. The water also contains approximately 100 ppm of carbon dioxide, but this concentration is reducible to 5 to 10 ppm by aeration. From this stratum the water division produces about 80 per cent of the city's water supply, and private industries pump one and one-half to two times as much more. The new pumping station will obtain its entire initial supply and the bulk of its ultimate supply from this stratum.

3. The 1,400-ft stratum which lies below the 500-ft stratum and is separated from it by approximately 300 ft of impervious clay. The water from this stratum is much softer than the water from the 500-ft stratum; it has little or no iron and considerably less carbon dioxide than the 500-ft stratum. The division's two existing plants pump approximately 20 per cent of their water from this stratum. This water is pumped into the same raw water basin as the water from the 500-ft stratum and receives the same aeration and filtration treatment. Some development of this stratum for the new plant is contemplated, but the wells are more costly to install than those in the 500-ft stratum, the sands are generally finer, and the water is produced in smaller quantity. In addition, the interference between wells is much greater.

4. The fourth stratum which has been tapped by the water division only once, at a depth of approximately 2,600 ft. The water from this strata is highly mineralized and much warmer than that from the upper strata. This water has never been utilized nor is its development contemplated for the new plant.

Selection of Site

Inasmuch as the entire water supply for Memphis comes from wells, and it is not economical to pump too large a quantity of water from any one area, a site removed from the two existing stations was selected for the new pumping station and well field. The site is in the southwest section of the city, 3.7 miles south of the Parkway station and 6 miles southwest of the Sheahan station. Thus, Memphis will have pumping stations in the north-central, southeastern, and southwestern sections of the city.

A potential site was selected in 1947 and an option was taken on the property. Test borings were made to determine the potentiality of the water-bearing sand. The site appeared ideal; it was close to a source of electrical power, on a railroad, and less than three miles from the high-value, uptown district, but unfortunately the sands were of rather poor quality. Additional borings were made approximately one mile east of this location and excellent sands were located. Another plant site was available which had most of the desirable features of the original site except that the distance from the power source, an electric substation, was approximately one mile. An option was taken on this site also.

Water Supply Plans

In 1949 the engineering firm of Black and Veatch was employed by the Board of Light, Gas, & Water Commissioners to make a thorough water supply report. This report was to consider ground water and surface water from the Mississippi River and the location and type of pumping—steam or electric—of the pumping plant if a third one was deemed advisable. The report recommended the construction of a station on the second site the division had under option, at which the test borings were favorable. The consultants were commissioned to design and supervise the construction of an electrically operated pumping station to be supplied with water from motor-driven, deep-well turbine pumps scattered through the area. The station, treatment works, collecting lines, and electrical distribution were to be designed by and constructed under the supervision of the consultants; the wells, well houses, and appurtenances were to be designed and constructed by the water division. The plant will have an initial capacity of 30 mgd; ultimately it will be increased to 42 mgd.

The new station, the Thomas H. Allen Pumping Station, will develop its water supply from a rectangle measuring approximately 4,000 ft from east to west and 13,000 ft from north to south. The land within the rectangle and adjacent to it has been developed or will be developed almost entirely for residential or park-type usage. A 150-acre municipal golf course lies almost in the center of the area. The nearest industrial well is approximately 3,000 ft from the edge of the rectangle.

The division plans to develop 15 wells initially, with an ultimate total of 37, each either on a lot owned by the division or on the perimeter of the golf course. Each well will be equipped with a motor-driven turbine pump housed in an attractive brick well house, architecturally designed to match the pumping station buildings. The electric service to the wells will be through an underground conduit system and will be so designed that only one well will be forced out of service by a single failure of cable, breaker, or transformer. The water will be delivered to the pumping station through a system of cast-iron collecting mains. These mains are large enough and are cross connected and valved in such a way that if a break or failure occurs in any section, the unaffected wells will still be able to deliver the full capacity of the plant. Each well may be started or stopped either from the control board at the station or at the well houses. Safety features, such as low-pressure indicators and sand traps, will be incorporated in the design to shut

off any well that is pumping sand in dangerous quantities.

Types of Wells

The wells will be either sand-wall or gravel-wall. The sand-wall wells, which will be drilled by the division's forces, will have brass screens or strainers with machine-cut slots approximately 0.010 in. wide. The gravel-wall wells, which will probably be installed by well contractors, will have coarser strainers of brass, silicon bronze, or stainless steel. These strainers will be surrounded by a cylindrical envelope, not less than 30 in. in diameter, of sized gravel. In both types of wells the casing will be of 18-in. or larger steel pipe, $\frac{5}{16}$ in. thick, and will extend from the base of the pump to the top of the selected strainer location in the water-bearing sands. The entire length of casing will be surrounded by a 2-in. shell of cement grout.

In the sand-wall wells, the strainers will be fastened to the casing by an expanded lead ring. In the gravel-wall wells, approximately 60 ft of 12-in. steel pipe will be fastened to the strainer and will extend into the 18-in. casing. The space between the pipe and the 18-in. casing will be filled with the graded gravel. All strainers will be 12 in. in diameter and will have from 60 to 80 ft of slotted area extending below the bottom of the 18-in. casing into the water-bearing sands.

Well Pump Requirements

The well pumps will have the double duty of raising the water to the surface and forcing it through the well-collecting system to the top of the aerator at the station site. The static water elevation in this area is 189.0 ft, mean Gulf datum. The elevation of the discharge of the well-collecting lines at the plant site is 319.0 ft (mean Gulf datum), a difference of 130 ft. In order to determine the total head requirements of the well pumps, it is necessary to add to this value the drawdown of the water level in the well when the pump is running, the field drawdown—the effect on the water level of pumping other wells in the field—and the friction loss in the well columns and the collecting mains.

Test borings were made at each well location. The sand samples obtained indicated that the average well drawdown would be approximately 1 ft for each 30 gpm pumped from the well, or a total of 35 ft at the 1,050-gpm rate. This estimate is probably conservative, however, as the average drawdown from the six wells already installed and pumped only amounts to 1 ft for each 40 gpm pumped. The general or field drawdown will amount to $1\frac{1}{2}$ to 2 ft for each million gallons per day pumped from the field. The higher figure—2 ft per mgd—was used in the division's calculations. It was then estimated that each pump should be able to deliver 1,050 gpm at a total head of 265 ft.

Specifications for gravel-wall wells and pumps and for sand-wall wells and pumps were prepared. Pump contractors will be required to supply and install the pumps and motors. The pumps are to have bronze impellers and bronze bowls 14–15 in. in diameter, and are to be oil-lubricated. Interchangeable sections of steel or wrought-iron pipe, 12 in. in diameter and not more than 20 ft long, will comprise the suction and discharge piping. The bottom 20 ft of both the discharge column and the shaft enclosure will be

of brass, with the rest of the shaft enclosure, or oil pipe, of extra heavy steel pipe. The motors will be rated at 100 hp, 440 v, and 1,150 rpm, and will be equipped with combination magnetic cross-the-line starters. These starters will have auxiliary connections enabling the pump to be started or stopped either from the station or at the well, and they will also shut off the motor if the well begins to pump sand in dangerous quantities. The number of stages in the pumps will be determined by the pump manufacturer, but preference will be given to pumps with the least number of stages producing a satisfactory and efficient operation. The depth of the pump setting will vary directly with the ground elevation and will range between 180 and 220 ft.

Well House and Grounds

Each well house will be constructed directly over a well and will house the pump, starter, propeller type water meter, electric meter, sand indicator, electric transformer (12,000/440-v, askarel-filled), and a three-way, line-break electric switch (12,000-v, oil-filled). An electric transformer, a switch, and a small lighting transformer will be separated from the well pump and starter by steel grillwork in one end of the building.

Anchor bolts will be installed in the parapet walls of each well house to facilitate the erection of a derrick for servicing the pump or motor. A large hatch with a double door 5 ft wide and a removable louver section above it will be incorporated in the roof. This opening will permit the removal of the pump for servicing.

The well lots average approximately 100 × 200 ft. They will be graded and landscaped, and subsequently will be maintained by the division's crews so that they will give the appearance of small and attractive parks. The maintenance of well lots in an attractive manner has paid a dividend in good will far in excess of the cost. Instead of meeting opposition from adjoining property owners, the use of lots for well locations frequently is responsible for the purchase of adjoining lots at premium prices by home builders.

The Thomas H. Allen Pumping Station will probably begin operation by the spring of 1953. Discharge connections have been made from the six wells already completed directly to the distribution system. Because the water produced by these wells cannot be aerated or filtered, small chemical feed pumps have been installed at each of the six wells and sodium hexametaphosphate will be added to prevent the iron from precipitating. Thus, the division was prepared to augment its water supply by the summer of 1951.

References

1. McClintock, James R. Recent Water Developments at Memphis. Jour. AWWA, **10**:1056 (Nov. 1923).

Aeration Experiments at Memphis, Tenn.

By R. L. Brown

A paper presented on Oct. 24, 1950, at the Kentucky-Tennessee Section Meeting, Memphis, Tenn., by R. L. Brown, Civ. Engr., Black & Veatch, Consulting Engrs., Kansas City, Mo.

MEMPHIS is fortunately located over an abundant supply of soft ground water from which the city supply is obtained. Each of the two pumping stations, the Parkway and the Sheahan, has its own satellite well field in different parts of the city. These stations maintain pressure in the distribution system. The problems involved in the design of the Parkway Station were discussed by McClintock (1) in 1923.

The two most productive levels for well water development are the 500- and 1,400-ft sands. The 500-ft sand is the more productive of the two and is, consequently, more exploited. Table 1 gives some of the more important chemical characteristics of the water from the two aquifers.

For many years, Memphis pumped water from flowing artesian wells directly into the city mains. The discoloration from iron and the taste and odor from hydrogen sulfide made this practice objectionable. But surprisingly little corrosion of the distribution mains occurred during this period.

In 1922 Donaldson (2) experimented with various types of aerators to determine the most practical type and to ascertain the possibility of removing dissolved gases by simple aeration, and iron by sand filtration. The coke tray aerator and the simple aeration and sand filtration methods were found practical.

The design of the Parkway Pumping Station, completed in 1924, was based on Donaldson's experimentation. Water is pumped from individual wells by the air-lift method and is brought by gravity collector lines to a raw water reservoir. Most of the hydrogen sulfide is removed at the wells by the air lift, and the carbon dioxide content is reduced to about 35 ppm. The water is repumped to a group of coke tray aerators. The individual units consist of a copper plate perforated with $\frac{1}{8}$-in. holes on 1-in. centers, over which water flows by gravity from a central riser. These plates distribute water over five coke trays arranged in vertical tiers with 1 ft 4 in. between trays. The tiers are about 4 ft apart and are housed in a rather small building with comparatively little open wall space.

The original coke tray bottoms were coarse brass wire. According to the late F. A. Mantel, Memphis Water Dept. chemist, the wire corroded in about one year. It was replaced by bottoms made of $\frac{1}{2} \times 2$-in. cypress slats spaced 2 in. apart. The cypress slats lasted much longer than the wire.

The Parkway Station has operated successfully for many years. The principal objections to the aerator

have been the daily sweeping required to keep the dosing tray holes open, and the severe deterioration of the building concrete. This deterioration was caused in part, by the corrosive action of hydrogen sulfide and carbon dioxide gases which resulted from inadequate ventilation and excessive dampness.

The Sheahan Pumping Station was completed in 1934. The same general aerator design as at Parkway was followed, but more open wall space was provided in the aerator building. There is little evidence of concrete deterioration in the Sheahan Station, but the operation of the perforated-plate dosing tray is not entirely satisfactory,

TABLE 1

Chemical Characteristics of Memphis Water

Characteristic	500-ft Level	1,400-ft Level
Temperature—°*F*	64	70
pH	5.9	7.0
Fe—*ppm*	0.8	1.3
CO_2—*ppm*	100	15
H_2S—*ppm*	0.4	0.0
Total Hardness—*ppm*	35	9

and the flume-to-dosing tray arrangement does not result in as uniform distribution as is desirable. Water also tends to bunch and does not remain uniformly distributed when it passes through the slat bottoms of the coke trays. Bunching is particularly bad at rates of flow between 25 and 30 gpm per sq ft; 30 gpm per sq ft is the design rate for the station.

The amount of water available from air-lift wells has become insufficient and new wells from which water is pumped by turbine type, deep-well pumps have been drilled. There is no carbon dioxide or hydrogen sulfide loss before aeration in water pumped by this method, and as a result, when the station is operating at design capacity (30 mgd), water delivered to the aerator has a carbon dioxide content of 48 to 50 ppm. After aeration and filtration, the concentration is 14 to 20 ppm.

Recent Experimental Work

Memphis has, in the past, used airlift wells from which water flowed by gravity collector lines to a raw water reservoir at the pumping station. If this method were followed in the new station, a site higher than the well field could not be used. For the new Thomas H. Allen Station no site was available in the general location dictated by existing facilities which met this topographical requirement, and an isolated receiving and pumping station was not economical. Consequently, the new station will be supplied entirely by water pumped by turbine type, deep-well pumps and delivered directly from a collector main to the aerators. The carbon dioxide loading on the aerators will be 100 ppm instead of 30 to 40 ppm. It was necessary to redesign the aerator previously used in order to obtain an end point of less than 10 ppm carbon dioxide.

Because the method of carbon dioxide and hydrogen sulfide removal used for many years in Memphis has been succesful in meeting requirements, it was considered for use in the new station. These requirements include:

1. Removal by aeration alone without the addition of lime or any other chemicals

2. An aerator of the tray type

3. Aeration without the use of forced ventilation

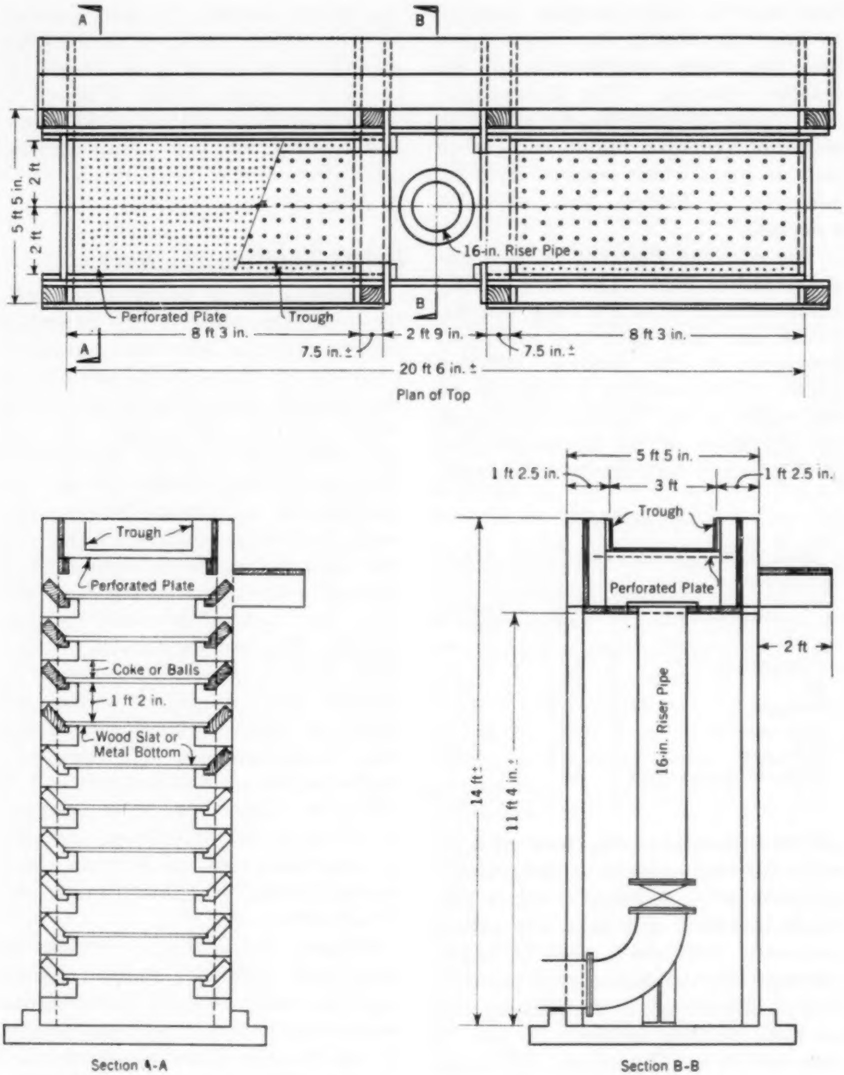


Fig. 1. Details of Plant-Scale Aerator

The two tiers of trays are supplied from a central riser pipe.

4. An aerator effluent containing less than 10 ppm carbon dioxide.

The aeration experiments indicated that all of these design requirements were successfully met. To accomplish them, the aerator designed and now under construction contains the following features:

1. The dissolved gases and iron will be removed by aeration and by filtration through a conventional, rapid sand filter, without the use of lime or any other chemical.

2. The aerator will be of the coke tray type. It will have a stainless steel distribution trough and a perforated dosing plate at the top with nine coke trays below, spaced 1 ft $3\frac{1}{2}$ in., center to center.

3. No provision has been made for forced ventilation. The sides of the structure housing the aerator units will consist mainly of an open pattern of aluminum grillwork, however, and will serve only to give architectural effect and prevent vandalism. The roof of the building will be of the penthouse type with the sides of the penthouse open.

4. An aerator effluent containing less than 10 ppm of carbon dioxide will be obtained.

Preliminary Aerator

The first experimental work was conducted with a preliminary aerator 4 ft square and approximately 14 ft high located in the parking area in the rear of the Sheahan Pumping Station. Subsequently, a plant-scale experimental unit was built and housed in a wooden structure with the same dimensions and approximately the same openings for ventilation as those proposed for the final aerator building.

The experimental aerator was operated intermittently for more than a year with water pumped from the "Getwell Field" by electric turbine pumps. Trays of $\frac{1}{4}$-in. hardware cloth and no packing media and various tray spacings and dosing rates were used in the first experiments. Carbon dioxide removal below 10 ppm was obtained with 20 trays and 6-in. spacing, center to center. Trays of flat metal plates perforated with $\frac{1}{8}$-in. holes, 1 in. from center to center, were also tried, but, because of pooling on the plates, comparatively little surface area was exposed and the results were poor. At 20 gpm per sq ft, the residual carbon dioxide was 18 ppm.

Ten slat-bottom coke trays spaced 1 ft apart were used in the next set of experiments. The first coke tried varied in size from $1\frac{1}{2}$ to $2\frac{1}{2}$ in.; poor results—13 ppm of carbon dioxide at 16 gpm per sq ft—were obtained. With larger coke—$2\frac{1}{2}$ to 5 in.—it was possible to obtain consistently an end point below 10 ppm carbon dioxide at rates of 20 and 25 gpm per sq ft. Probably the coarser coke provided larger voids between individual pieces, thus permitting better circulation of air through the coke packing. Results were better on windy than on calm days. The length of time the water was in the aerator was dye checked on numerous occasions and averaged 8.5 sec.

Uniform distribution from top to bottom is an important factor in obtaining top efficiency from a tray type aerator. The dissolved carbon dioxide molecules must come in contact with a wetted surface and must cross that surface in order to be liberated from the water. The better the distribution, the thinner the films of moving water over the coke packing, and the shorter the average distance of the dissolved carbon dioxide molecules to a surface.

To overcome the objectionable poor distribution from the slat bottoms, a corrugated metal bottom, perforated in the peaks and valleys of the corrugations, was tried. Also, balls 3 in. in diameter made of Vermiculite *

* A micaceous mineral product of International Vermiculite Co., Girard, Ill.

and cement were tried as packing media on the assumption that the circulation of air through the media would be better with a uniform packing media. Results with the metal bottoms and balls were not conclusive in the preliminary apparatus, however, and further experimentation was required with the plant-scale unit.

Some experiments were conducted to determine the efficiency of iron removal when the effluent from the experimental aerator was filtered immediately after aeration—the procedure planned for the new station. An experimental sand filter 10 in. square was constructed and the effluent from the experimental aerator was filtered through it at 2 gpm per sq ft. The filtered effluent contained only a trace of iron.

At the same time, another portion of effluent was filtered through fine filter paper, but practically no iron was removed. This experiment indicates that sand filtration is not primarily a straining process and coincides with the findings of Stein (3), who experimented extensively at Massachusetts Institute of Technology.

Regardless of the mechanics of the filtration process, chemical analysis of all samples of sand-filtered effluent from the experimental aerator indicated that good iron removal should be obtained with the proposed type of treatment.

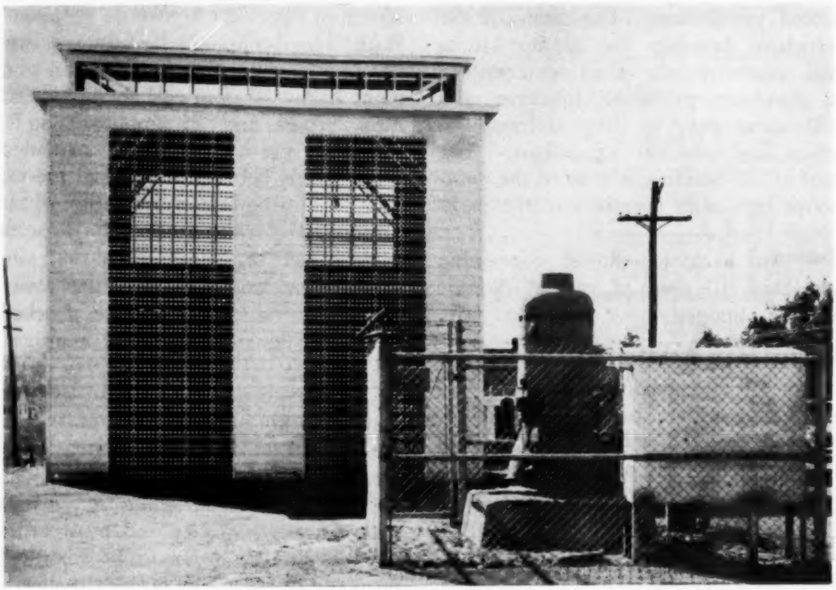


Fig. 2. Aerator Building

The lattice strips have been removed to provide 60 per cent clear opening.

Plant-Scale Aerator

Experiments were conducted with the plant-scale aerator in order to answer five questions:

1. Is an aerator in a well-ventilated building as efficient as one in the open?

2. To what extent will normal variations in atmospheric conditions affect the efficiency of an aerator with no forced ventilation?

3. Is the corrugated metal bottom more efficient than the wood-slat bottom previously used, and is there any advantage in using balls instead of coke as packing media?

4. What is the optimum tray spacing?

5. Would certain proposed structural changes improve initial distribution of the incoming water?

Basic features in the design of the plant-scale aerator and the dimensions adopted for final design are shown in Fig. 1. The plant-scale aerator consisted of two tiers of trays of the same dimensions, both of which were supplied with unaerated water from a central riser pipe. One tier of trays with coke on wood-slat bottoms was used as a standard for comparison during the experiment. The other tier was first packed with balls on corrugated metal bottoms, but later the balls were replaced with coke and the tray spacing was varied.

The corrugated metal bottoms were made by punching sheets of 20-gage stainless steel with alternate rows of $\frac{13}{32}$-in. round and $\frac{11}{16}$-in. square holes. The rows were $1\frac{1}{16}$ in. apart and the holes in each row were 1 in. from c to c. The plates were corrugated by bending 90 degrees on the center line of the rows. The corrugated plates were placed in the aerator so the square holes were at the peaks of the corrugations and the round holes were in the valleys. The aerator was operated daily, except Sundays, for approximately one month. Samples for testing were taken simultaneously from the effluent of both tiers of trays.

The first results with the plant-scale unit were rather discouraging; they were erratic, and good only when there was a stiff breeze blowing through the aerator building. Although the grill area on the sides of the building housing the aerator was large, the pattern of the grillwork was a wood lattice which provided 25 per cent clear opening. When enough of the lattice strips were ripped off to provide 60 per cent clear opening, more consistent results were obtained. On calm days, some samples tested contained more than 10 ppm carbon dioxide, and on brisk days, samples tested as low as 3 ppm carbon dioxide. The structure housing the aerator is shown in Fig. 2, after the lattice strips were removed. One of the wells in the Getwell Field is in the foreground.

A study of all tests indicated that corrugated metal bottoms were more efficient than wood-slat bottoms and that balls as packing media were no better than coke. Figures 3 and 4 show the distribution pattern of the water after passing through the wood-slat and metal bottoms, respectively.

The general conclusions from experiments with tray-type aerators and with Memphis water, pumped directly from the 500-ft aquifer by deep well turbine pumps are:

1. Carbon dioxide is removed most efficiently if the aerator is designed to spread the water uniformly over the packing media in thin moving films, and is so arranged that atmospheric air continually passes over these films. These factors are equally important.

2. It is impossible to secure consistently uniform results with an aerator dependent on natural ventilation alone. Fairly uniform results will be obtained

if the unit is not housed and if natural ventilation is not obstructed by other buildings.

3. If coke packing is used, the coke should be not less than 2 in. or more than 6 in. in size.

Figure 1 shows that the head loss through the new aerator will be 13 ft. The time required for water to pass from top to bottom will be slightly more than 8 sec. The pH is 5.9 for raw water and 7.1 for aerated water.

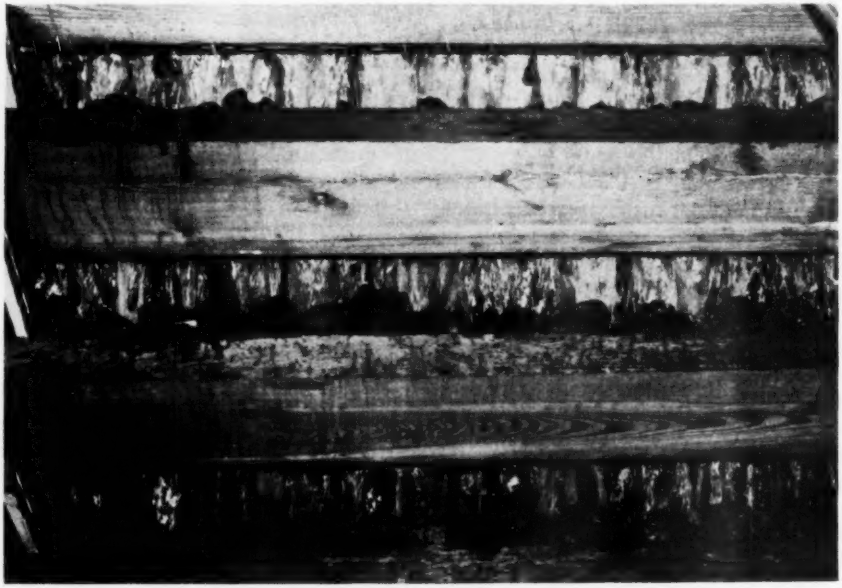


Fig. 3. Wood-Slat Bottom Aerator Trays

The water distribution obtained is inferior to metal bottoms shown in Fig. 4.

More than 11 tons of carbon dioxide will be removed every 24 hr, or almost 1,000 lb per hr when the new 30-mgd station is operated at capacity. The iron removed by the filters in 24 hr will total only 250 lb.

Importance of Aeration

An interesting experiment has recently been conducted by the Water Div. at Memphis to demonstrate the importance of efficient aeration and good carbon dioxide removal. Well water was pumped directly into an isolated section of the distribution system to determine whether it would be practical to augment the existing filtered supply in this manner temporarily.

Samples from the distribution system were collected some distance from the point at which the well water was introduced. The samples were clear when taken, indicating that all the chemical contents were in solution. Chemical tests showed that the samples contained about 10 ppm iron, whereas the well water contained less than 1 ppm iron. There is apparently some critical point between the pH of the aerated and filtered water and the pH of the unaerated well water, below which a mixture of the two waters is

aggressive. Experience has shown conclusively that the well water, after aeration and filtration, is not corrosive.

Experience Elsewhere

A water treatment plant, designed by the author's firm to remove dissolved gases and iron from a well water supply, was put into operation at Caruthersville, Mo., in the fall of 1950. This town is on the Mississippi River about 100 miles north of Memphis and the treatment problems involved are similar to those encountered with the Memphis well supply. Table 2 gives some of the chemical characteristics of the untreated water.

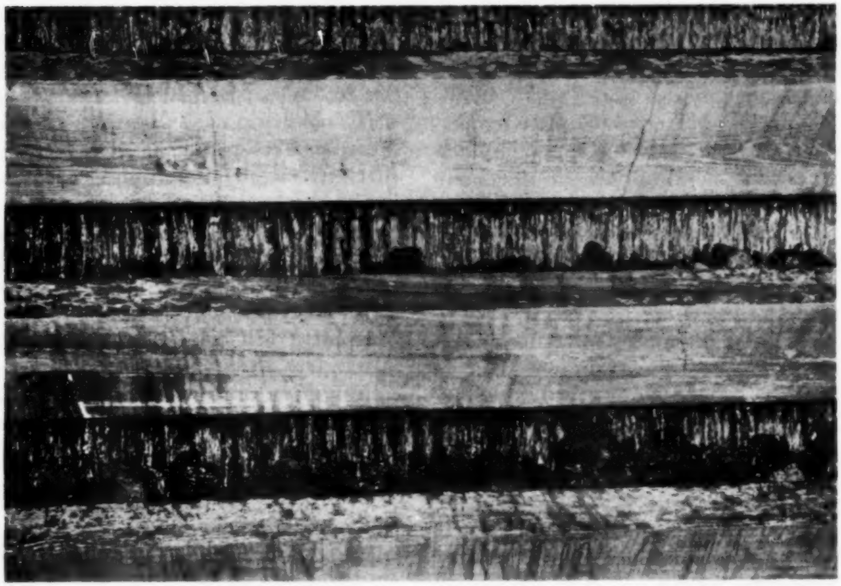


Fig. 4. Metal Bottom Aerator Trays

The water distribution is more efficient than that obtained by wood slat bottoms.

In Caruthersville the water is first aerated in a tray type aerator. There are six coke trays and the head loss from top to bottom is 9 ft. The aerator is shaded by a roof but is otherwise in the open. Under normal operating conditions the aerator dosing rate is 15 gpm per sq ft. Aeration is followed by conventional rapid sand filtration. The time elapsing between aeration and filtration is less than an hour. No lime is added in the treatment process. After filtration, only a trace of iron remains. The filtered water was tested for free carbon dioxide on five successive days in the spring of 1951 and on five successive days six months later. The carbon dioxide content varied between 3 and 5 ppm for all tests.

At Smith Center, Kan., an iron removal problem created by a well supply has also been investigated recently. Some of the chemical characteristics of the well water are given in Table 3.

After aeration in an existing aerator (not of the coke tray type), the wa-

TABLE 2

Chemical Characteristics of Caruthersville, Mo., Water

Temperature—°*F*	82
pH	6.2
Fe—*ppm*	4.2
CO_2—*ppm*	75
H_2S—*ppm*	0.6
Total Hardness—*ppm*	24

TABLE 3

Chemical Characteristics of Smith Center, Kan., Water

Temperature—°*F*	56
pH	7.1
Fe—*ppm*	8.7
Mn—*ppm*	1.5
CO_2—*ppm*	50
H_2S—*ppm*	0.4
Total Hardness—*ppm*	366

ter is passed through a rectangular sedimentation basin with a theoretical retention period of 3 hr, and then filtered in a conventional rapid sand filter. With this type of treatment alone, the filtered water still contains 1.1 ppm iron and 0.98 ppm manganese. By the addition of 3 ppm chlorine after aeration, the iron content of the filtered water is reduced to 0.67 ppm and the manganese content is reduced to 0.88 ppm. Additional steps are being taken to reduce the iron and manganese content further.

Why the dissolved iron is more rapidly oxidized in one water than in another cannot be readily explained. The temperature of the well supply is probably significant. There is an approximate rule that the rate of a chemical reaction is doubled with every 10-deg increase in temperature. The complete answer may involve other important factors.

Acknowledgments

Memphis has pioneered in the field of aeration and iron removal. The work just concluded is an added chapter in the meager literature on this subject.

The experimental work was conducted under the general supervision of C. M. McCord, Director of the Memphis Water Div., and E. L. Filby, Black & Veatch, Consulting Engrs. Design and operation of the experimental units were supervised by R. L. Brown of Black & Veatch, assisted by W. L. Samuel, on leave from the Alabama Polytechnic Institute. J. W. Murphrey, Chemist for the Memphis Water Div., made most of the analytical tests.

References

1. McClintock, James R. Recent Water Developments at Memphis. Jour. AWWA, **10**:1056 (Nov. 1923).
2. Donaldson, Wellington. Aeration Experiments for Removal of Carbonic Acid. Eng. News-Rec., **90**:874 (May 1923).
3. Stein, P. C. The Mechanism of the Filtration of Water by Rapid Sand Filters. Unpublished.

Design of New Treatment and Pumping Works at Memphis, Tenn.

By D. L. Blackwell

A paper presented on Oct. 24, 1950, at the Kentucky-Tennessee Section Meeting, Memphis, Tenn., by D. L. Blackwell, Civ. Engr., Black & Veatch, Consulting Engrs., Kansas City, Mo.

THE new 30-mgd Thomas H. Allen water treatment and pumping works will furnish Memphis with an increased supply of water and will help to balance pressures in the distribution system by maintaining more uniform pressures in the southern and southwestern districts. These features will become increasingly important as the industrial development planned on President's Island increases. Parkway feeds the downtown district from the north; the new station will feed the downtown district from the south and will thus provide additional fire protection to the high-value area.

Physical Plant

Water from the new well field will be pumped through three collecting lines directly to the new aerator. Following aeration, the water will flow by gravity to the filters through a 48-in. cast-iron pipeline. A 48 × 24-in. Venturi tube will be installed in this line to meter the water to be treated.

The filter building and the pumping station will be housed in one structure rather than separately as at Parkway and Sheahan, but the aerators will be housed in a separate structure. The filter plant and pumping station will be in opposite wings of the main building and will be separated by a central entrance lobby. Both buildings will be of modern brick and tile construction with monolithic, reinforced concrete substructures. The framework of the filter plant and pumping station will be structural steel but, because of the corrosive conditions present in the aerator, a reinforced concrete frame will be used for the aerator building. The architectural design for the new station has been planned by the Memphis firm of Furbringer and Ehrman.

Ten filters having a capacity of 3 mgd each, or a total capacity of 30 mgd, will be housed in one wing of the main building. The filters will be spaced in two rows of five each on opposite sides of a central pipe gallery. This arrangement will make possible a single influent header and wash-water sewer. Each filter unit will be divided into two sections by a central wash-water gutter. Each section will be 12 ft wide by 34 ft long, making a total filter area of 8,160 sq ft. The filters have been designed for a filtration rate of approximately 2.5 gpm per sq ft, a rate which has proved satisfactory at both Parkway and Sheahan.

All filter valves will be hydraulically operated and will be controlled from operating tables located on the filter operating floor. Loss-of-head and rate-of-flow gages for each filter will

be mounted on the respective operating tables. As at the Sheahan station, the rate controllers for the filter effluent will be automatically adjusted by a master control unit to maintain, within rather close limits, a constant water level on the filters, regardless of the rate of flow through the treatment works. This automatic adjustment will allow the well pumpage to vary without requiring manual adjustment of the filter rate controllers. The master control, which will be located on one of the filter operating tables, will also permit manual adjustment of the setting of all rate controllers.

Water for washing the filters will be stored in two 50,000-gal steel tanks housed in a tower above the central entrance lobby. These tanks have sufficient capacity, under normal operating conditions, to wash two filter units without refilling. They will be automatically refilled from the discharge piping of the high service pumps, the flow of which will be controlled by an altitude valve.

Although chlorination is not normally required, chlorination facilities will be available for treating the filter effluent if the need arises.

Treated water will flow by gravity from the filters into two underground, reinforced-concrete storage reservoirs. Each reservoir will measure 277 × 312 ft and at capacity will hold 15.5 ft of water, or 10 mil gal. The combined treated water storage at the three stations, with all reservoirs full, will therefore be approximately 63 mil gal. The piping between the filters and the storage reservoirs will be arranged so that the reservoirs can be by-passed, thus allowing the water to flow directly to the suction lines of the high service pumps should an emergency arise.

Reliability

The first and foremost consideration in the design of the new pumping station was reliability—the ability of the pumping works to deliver an adequate quantity of water into the distribution system 24 hr a day, 365 days a year, without interruption. As Memphis has no overhead storage, pressures in the distribution system can be maintained only as long as the high-service pumps are operating. Consequently, the high-service pumping facilities are one of the most vital links in the chain that starts with the extraction of the water from the underground source of supply and ends with its delivery to the point of ultimate consumption.

Memphis has a high underwriter's rating for a city of its size. As all of the water delivered into the distribution mains from the new station will be pumped electrically, the National Board of Fire Underwriters has set some rather rigid requirements for rating the new station. The Memphis Water Div., under the administration of Thomas H. Allen and C. M. McCord, has, for a number of years, more than complied with the underwriter's requirements. In keeping with this policy, the new station was so designed that a major equipment failure or a complete loss of electric power would not interrupt pumping for more than a few seconds.

Four high-service pumps will ultimately be installed in the new pumping station although only two will be installed initially. Each pump will have a rating of 15 mgd at 180 ft total pumping head. The pumps will be driven by variable speed, wound-rotor electric motors (600-hp, 2,400-v) with drum type slip controllers and resistors for speed control. Although

the initial pumping capacity will be only 30 mgd, installation of the future pumps will increase the total installed pumping capacity to a maximum of 60 mgd, with a firm capacity of 45 mgd.

The high-service pumps will be horizontal, double-suction, split-case, centrifugal pumps, but will vary from conventional design in having the bottom-suction, bottom-discharge pattern.

The capacity of each pump can be varied from 5 to 15 mgd by varying the speed either manually or automatically. Automatic control will be maintained by a pressure type controller which will vary the pump speed as required to maintain a constant station discharge pressure. As the pumps will be located on the pump station operating floor slightly above high water level in the storage reservoirs, a vacuum type pump priming system with vacuum tank and duplicate vacuum pumps will automatically keep all pumps primed and ready to operate.

Each pump discharge line will contain a Venturi tube for metering the water pumped. Cone type check valves, cylinder-operated automatically by oil, will be installed at the throat of the Venturi tubes. An oil accumulator system consisting of an oil sump, oil pressure tank, duplicate oil pumps, and duplicate compressors will be provided. Check valve controls on the pump discharge lines will be arranged so that the check valve cannot open until the pump has started and reached its minimum running speed. This operation will be accomplished by controlling the pilot device which initiates the opening of the check valve from a pressure switch in the pump discharge line. When the pump motor control switch is thrown to stop a running pump, the check valve will start to close but the pump will not actually stop until a limit switch on the check valve interrupts the motor circuit. The limit switch will interrupt the motor circuit—to stop the pump—when the check valve is approximately 90 per cent closed. An overriding control will automatically close all check valves simultaneously in approximately six seconds when power failure occurs. This system of control will make reversal of flow through the pumps virtually impossible.

All high-service pumps will be connected to a common discharge header, from which, ultimately, four 36-in. discharge mains will leave the station and connect to widely separated points in the distribution network. The header will be looped and will have sectionalizing valves arranged so that a break anywhere in the discharge piping, or the failure of any valve, cannot put more than one pump and one discharge main out of service. Thus, any single piping or valve failure would result in the loss of not more than 25 per cent of the ultimate pumping capacity of the station. The 45-mgd firm pumping capacity applies to the discharge piping as well as to the pumping facilities.

Power Supply

The normal power supply to the new station will include a 12,000-v circuit from one of the city's power substations and two emergency 12,000-v circuits from a generating station. All three circuits will be transmitted overhead to the edge of the station site and then underground into the station.

The three 12,000-v circuits will feed electric power to a modern, metal-clad, 12,000-v switchgear, the bus of which will be divided at the center so that

each of the two main bus sections can be fed either independently or simultaneously from the normal feeder circuit. Each emergency circuit will supply one of the main bus sections. Transfer to the emergency circuits will be automatic if the normal circuit fails. As the normal and emergency sources may not always be synchronized, interlocking and protective relaying will be installed to prevent paralleling of the sources. On the other hand, provisions will be included to permit transfer from one source to the other without an interruption of electric power, when the sources are synchronized.

Power from the 12,000-v switchgear will be fed to two station power transformers—2,000-kva, 12,000- to 2,400-v—and to three underground well-feeder circuits. One of the well-feeder circuits will serve a few wells to be located north of the new station. The other two well-feeder circuits will feed the main well field to the southeast of the new station. These two circuits will form an electrical loop which can be energized from either or both sides of the divided 12,000-v bus. A 12,000- to 480-v transformer will be installed in each well house to provide electrical power for operation of the 480-v well pump motors. Switching facilities for disconnection at each well will permit opening the electrical loop at any well. This switching arrangement will permit isolation and repair of any faulty section of the feeder loop without discontinuing the operation of any of the wells.

The low voltage side of the station power transformers will feed a 2,400-v, metal-clad switchgear. This switchgear will be of the "double bus-double breaker" type consisting of two duplicate sections, back to back, each complete with its own bus and breakers, thus providing full duplication of all 2,400-v switchgear facilities. From this switchgear, power will be supplied to the 600-hp, high-service pump motors and to two 200-kva, 2,400- to 120/208-v, auxiliary power transformers which in turn feed a metal-enclosed 120/208-v switchgear.

With the divided-bus 12,000-v switchgear, the "double bus-double breaker" type 2,400-v switchgear, and the duplicate power and station transformers, one half of each component could fail completely without disrupting station operations. All duplicated switchgear and transformer facilities will have a rating sufficient to permit either of the duplicate units to handle peak ultimate station and well-field electrical power demands.

Three electrical generating units with diesel engines will ultimately be installed in the new station to serve as additional standby power source, but only one unit will be installed immediately. Thus, continuous operation of the pumping station will be assured even though all outside sources of power should fail. Each unit will generate electric power at 2,400 v and will have an output capacity of 1,000 kw. Power from the generators will be fed through the 2,400-v switchgear to operate the high-service pumps and station auxiliaries. All excess power can be fed through the station power transformers, using them as step-up transformers, to the wells. With a treated water storage of 20 mil gal, continuous operation of the wells will be secondary to continuous operation of the high-service pumps. Facilities will also be included on the 2,400-v switchgear for automatically synchronizing the generators with the outside power sources.

Compressed air will be used to start the diesel engines. A battery of high-pressure air tanks will be kept filled by an electric-motor-driven air compressor. A standby air compressor will be driven by a small gasoline engine. The diesel lubricating oil will be kept warm and circulating at all times so that only seconds will be required to start the engine and apply the generator output to the line.

The circulating water system for the diesel jackets will be a closed system with a tube type heat exchanger installed in the line. The circulating water will be cooled by passing station high-service water through the jacket water heat exchanger. The cooling water will not be wasted but will be returned to storage. The lubricating oil will also be cooled by bleeding high-service water through the lubricating oil cooler. As only a relatively small quantity of water will be required to cool the lubricating oil, it will be wasted rather than risk leakage of oil into the treated water supply.

Diesel fuel oil will be stored in the two 25,000-gal underground steel storage tanks and will be pumped to the fuel oil day tanks as needed. The fuel oil storage tanks can be filled either from tank trucks or from tank cars on the railroad spur serving the station. Fuel oil unloading and transfer pumps will be housed in a small fuel oil pumphouse near the storage tanks. As the new station will be located in a residential area, the diesel intake and exhaust noises will be silenced to the highest degree possible.

A 10-ton electrically operated traveling crane with motorized hoist will aid in servicing the high-service pumps and the diesel generator units. This crane will span the full width of the pump room—approximately 48 ft.

Control System

Normal operating control of the entire pumping station will originate from an electrical benchboard located in a control room adjacent to and within sight of the pump and diesel room. The high-service pumps can be started and stopped, placed under manual or automatic speed control, and adjusted for speed from this benchboard. Instruments will indicate the speed and the electrical characteristics of each running pump motor. Control and supervision of the outside power sources will also be incorporated into the benchboard. In emergencies resulting from failure of the control circuits, and in circumstances which require operating a diesel-generator unit, it will be possible to operate the entire pumping station from the control devices on the 2,400-v switchgear.

Remote control and supervision of all wells will originate from a well control center built into one end of the electrical benchboard. Indicating lights will show the operating status of each well. The well pumps can also be started and stopped from the well houses.

At the opposite end of the benchboard, a valve operating table will provide remote control of all hydraulic station-discharge and sectionalizing valves. Indicating lights on a "mimic" bus will show the position of each discharge and sectionalizing valve and of each pump-discharge check valve.

A water instrument panel will be built into the control room wall behind the electrical benchboard. Instruments mounted on this panel will:

1. Indicate, record, and totalize the raw-water pumpage
2. Indicate, record, and totalize the discharge from each high-service

pump and the total station discharge

3. Indicate and record the station-discharge pressure
4. Indicate and record the water depth in each treated water storage reservoir
5. Indicate the water depth in the wash water tanks.

Chart storage space has been provided behind the instrument panel.

Control of the diesel auxiliaries and such station auxiliaries as the oil accumulator equipment, the vacuum priming equipment, and the station air compressor will originate from metal-enclosed control centers located near the equipment to be controlled. These control centers will be energized from the 120/208-v switchgear. Power for station lighting will also be supplied by the 120/208-v switchgear through conventional breaker type lighting panels.

A station battery located in a separate battery room will supply d-c power for the operation of switchgear and control equipment, small d-c motor-driven auxiliaries, and a limited amount of emergency d-c lighting. Conversion to the emergency d-c lighting will be automatic if power failure occurs.

An annunciator system to indicate unusual or hazardous conditions will be provided. One set of visual signals will be located in the control room on the water instrument panel, and a duplicate set of signals will be located in the switchgear room. A separate annunciator system will be used with each diesel. An alarm horn will warn the operator to check the annunciator signals to determine what unusual or hazardous conditions exist. This horn can be silenced only from points near the annunciator visual signals. Unusual or hazardous conditions to be annunciated include:

1. Disagreement on the 12,000-v, 2,400-v, and 120/208-v switchgear
2. High temperature of the station power transformers
3. Low oil level in the station power transformers
4. Disagreement at the well control center
5. Loss of prime of any of the high-service pumps
6. High and low station-discharge pressures
7. High and low oil accumulator system pressures
8. High and low diesel lubricating oil pressures
9. High and low fuel oil levels in the day tanks
10. High diesel engine temperature.

Additional Facilities

Duplicate gas-fired steam boilers, centrally located in a basement boiler room, will furnish steam heat to the pumping station and filter plant. In keeping with the reliability built into the pumping station, each boiler will be capable of carrying the entire building heating load and will be equipped with standby oil-firing facilities.

Other facilities will include an office, an office storeroom, a chemical laboratory, and an assembly room for staff meetings and instructions. Washrooms, workshops, janitors' closets, and storage space will also be provided. A hydraulic freight elevator will serve the basement storage area.

A parking area and a small garage for housing the cars of the personnel will be located behind the pumping station. A spur track into the station site will serve an unloading dock in the rear of the pumping station. Trucks will also have access to this dock.

Perspective in Planning Water System Improvements

By William G. Riddle

A contribution to the Journal by William G. Riddle, Sr. Engr., Burns & McDonnell Engineering Co., Kansas City, Mo.

IT is not uncommon for those engaged in the administration, operation, and design of water works facilities to think of the individual components of water systems as if they were isolated units with specific characteristics and problems rather than integrated and interdependent parts of a complete, organized system. This tendency is believed to be particularly strong in dealing with high-service pumping facilities. It is extremely easy, and sometimes extremely unfortunate, to draw conclusions on pump operating conditions with inadequate regard to suction and discharge characteristics for varying rates of delivery. In a typical direct-pressure system, involving a high-service pumping station, transmission mains, and distribution network, the head-capacity characteristics of the system as a whole must be ascertained before the selection of pumps can be intelligently made.

Determination of System Characteristics

Various methods exist for determining the head-capacity characteristics of a system. The selection of method is guided generally by the specific peculiarities of the system, with consideration for such factors as its size and complexity and its general susceptibility to simplification without loss of reasonable precision. In a very small municipal or industrial water system, for example, the piping network may lend itself to such simplification that direct determination of head loss in successive increments of piping under the imposed demands is possible. The same type of determination may also be possible in large, but comparatively simple, industrial and military installation systems.

In general, however, head-capacity characteristics of the typical water transmission and distribution system can be economically ascertained with satisfactory precision only through adequate hydraulic analyses of the system. Such analyses, of course, can be appropriately utilized not only for reproducing past conditions of record, but for projecting the system into the future in order to determine its functional characteristics when operating under the demands and conditions that are predicted for that time.

Once the system head-capacity data are known, it is possible to relate them to the operational characteristics of the existing or contemplated pumping facilities so that overall system performance can be determined. In considering improvements to an existing high-service station, the hydraulic peculiarities of the system may be found quite interesting and revealing. In the

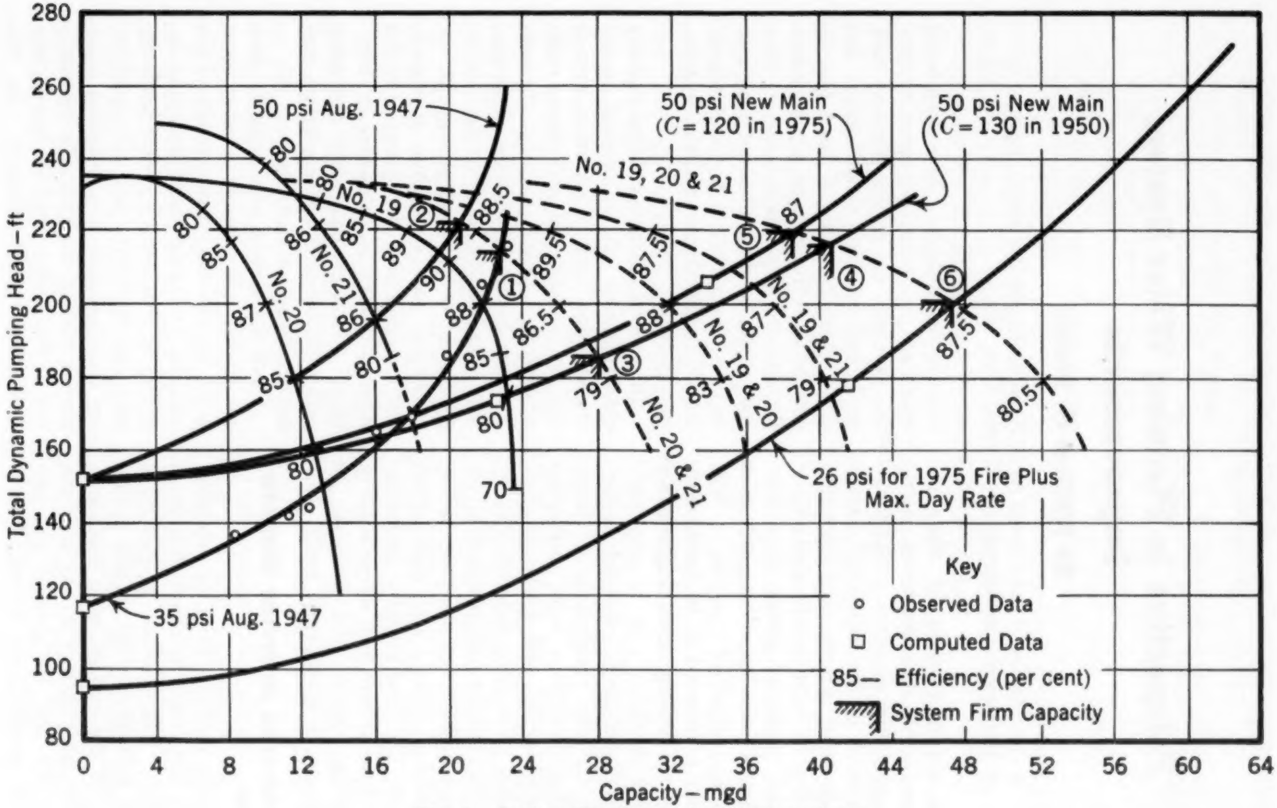


Fig. 1. System Head-Capacity Characteristics

System firm capacities are as follows: Existing: ①—22.8 mgd, ②—20.6 mgd; Proposed: ③—28.0 mgd, ④—40.7 mgd, ⑤—38.6 mgd, ⑥—47.4 mgd. Pressure designations on heavy curves are for system head downtown.

TABLE 1

System Head-Capacity Data

(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Pressure at Pumping Station (Centerline el 577)			
Hour	High-Service Pump Discharge *mgd*	Pressure Downtown (Centerline el 603) *psi*	Actual *psi*	Adjusted to 35 psi Downtown *psi*	El of Hydraulic Gradient at Pumping Sta. *ft*	Total Dynamic Head on Pumps Col. 6 −567* *ft*
1 AM	8.4	38	58	55	704	137
6 AM	11.4	37	59	57	709	142
7 AM	18.0	35	69	69	736	169
8 AM	21.8	34	84	85	773	206
9 AM	23.2	33	87	89	783	216
9 PM	19.9	43	84	76	753	186
10 PM	16.1	43	75	67	732	165
11 PM	12.5	40	63	58	711	144

* El 567 = mean water level in clear well.

course of studying the high-service pumping facilities for one of the midwestern metropolitan systems, for example, the performance characteristics of the centrifugal pumps were determined as shown in Fig. 1. The head-capacity curves of the existing three high-lift pumps are shown as light solid lines labeled No. 20, 21, and 19. In accordance with standard procedure, the capacities of these units were combined into the four possible operating combinations portrayed by the light dashed curves. From operating records during a preceding maximum day, data were assembled and analyzed as shown in Table 1, in which the pressures in the pump discharge header, shown in Column 4, were adjusted to an assumed hydraulic plane which would result in uniform downtown pressures of 35 psi, as shown in Column 5. Using these values, the gradient elevation at the discharge header and the total dynamic head in feet of water were determined for the various delivery rates, as shown in Columns 6 and 7, respectively. The data in Columns 2 and 7 were plotted to form the basis for the curve which delineates system head for 35 psi in the downtown area.

Under the then prevailing conditions of operation, approximately two-thirds of the high-service pump discharge was being delivered to the downtown area through approximately 6½ miles of 30-in. pipeline with velocities in excess of 4.5 fps. Under those circumstances it is not surprising that the system characteristic curve represents friction head losses which vary substantially as the 1.85 power of the quantity leaving the pump discharge header.

As the pressures prevailing downtown were consistently inadequate for providing satisfactory service, it was recommended that system improvements be based on maximum-hour pressures of not less than 50 psi. This condition was conveniently depicted in Fig. 1 simply by transferring the system characteristic curve vertically to the appropriate position on the total dynamic head scale.

Examination of the system curve in its relationship to the pump characteristic curves reveals clearly: [1] the pressing immediate inadequacy of the transmission capacity then available; and [2] the comparative immediate adequacy of the available high-service pumping capacity if the transmission bottleneck were relieved.

Hydraulic Analyses

To complete the discussion of Fig. 1 it may be noted that, based on both past and predicted future maximum demand conditions, hydraulic analyses of the transmission and distribution system were performed to check the adequacy and economy of tentative design for reinforcing that system. The analyses were performed in accordance with the Hardy Cross method as modified by Doland (1) and Kincaid (2). System characteristic curves were then drawn delineating maximum-hour conditions as they would have prevailed on the improved system in 1947 and as they are predicted to obtain on the improved system in 1975. Similarly, an analysis was performed and system characteristics were graphically represented for the demand condition resulting from a major fire occurring in the congested value district during a typical future maximum day.

For the reader's convenience, system firm capacities have been located and given a numerical designation for the various conditions considered and described. It may be seen that, without the addition of a fourth high-service pump, the contemplated additional transmission capacity will increase the firm capacity of the system from 20.6 to 28.0 mgd while maintaining the desired minimum pressures downtown. The firm capacity designation points 4, 5, and 6, will be valid after the installation of a new pump in the future.

The beneficial effect of the augmented transmission capacity is quite striking. Equally evident is the complete bottleneck that persists for the existing pumping facilities if capacity considerations are confined to the pumping station only, rather than expanded to embrace the entire water transmission and distribution system.

With specific reference to the foregoing example, it should be observed that the system studied does not have elevated storage as a materially effective component. Unusual hourly demand characteristics of this system are such as to reflect unfavorably on the economics of elevated storage. The existence of effective storage in appreciable extent, however, would not affect the analytical procedure adversely nor would it have significant effect on Fig. 1, other than as a reduction in the delivery rates from the pumps in response to feed from the elevated storage into the system.

Efficiencies

It can be observed in Fig. 1 that the pump operation contemplated for minimum desirable downtown pressures after transmission capacity has been augmented, would apparently result in inferior efficiencies for some combination of units. Actually, the pumps will normally operate higher on their characteristic curves in the range of more favorable efficiencies with system pressures above the desired minimum. For fire flow conditions, of course, station efficiencies are materially inferior. As the periods involved are of such short duration, however, it follows that efficiency considerations for this condition are of minor significance.

Conclusions

In conclusion, four points may be made:

1. It is desired to re-emphasize the importance of maintaining perspective while examining the individual components of a water system.

2. It is imperative to relate high-service pump operation to the combined functional characteristics of the transmission and distribution system.

3. Functional characteristics can be ascertained economically and with justifiable precision through the use of the Hardy Cross method of system analysis.

4. Not only is water system operational economics a prime consideration; but, further, functional capability of the system may be impaired seriously if improvements are not based on analytical studies which are all-embracing in scope.

References

1. Doland, J. J. Simplified Analysis of Flow in Water Distribution Systems. Eng. News-Record, **118**:475 (Oct. 1, 1936).

2. Kincaid, R. G. Analyzing Your Distribution System. W. W. Eng., **97**:72; 286; 482; 920; 1238 (1944).

Correction

In the paper "Counterflow Regeneration of Cation Exchanger in Partial Demineralization of Brackish Waters" by K. S. Spiegler, Walter Juda, and Morris Carron, which appeared in the January 1952 Journal, Reference 9 on p. 88 was incorrectly printed. The correct designation for the reference is:

9. Telkes, M. Solar Distillation to Produce Fresh Water From Sea Water. Am. Chem. Soc., 119th Meeting, Boston, Mass. (1951).

On p. 83, column 1, under "Pilot Plant," the third sentence should have read, "The cation- and anion-exchange columns were each 8 ft high." Also, on p. 87, column 1, line 7, the word "chemical" should have been deleted.

Calculation of Effect of Temperature on pH, Free Carbon Dioxide, and the Three Forms of Alkalinity

By John F. Dye

A paper presented on Sept. 21, 1951, at the Michigan Section Meeting, Benton Harbor, Mich., by John F. Dye, Chief Operator, Water Conditioning Plant, Board of Water & Elec. Light Comrs., Lansing, Mich.

THE fact that temperature exerts an important effect on the pH and carbonate equilibria in water appears to have been recognized in a general way for years, but the quantitative implications of this effect have not, until recently, been emphasized to water works operators. When Langelier (1) proposed his saturation index and also suggested that carbonate and bicarbonate alkalinities be computed by means of equations based on mass laws, he recognized the fact that temperature would have some effect upon the pH and the saturation index. Later, DeMartini (2), in a study which indicated the practical value of Langelier's saturation index, proposed similar equations for computing the free carbon dioxide content and the hydroxide alkalinity of waters, but, except for a general statement, scarcely mentioned temperature effects, probably because a detailed study of this particular phase was outside the scope of his investigations.

In 1939 Moore (3) presented the first graphical means for the determination of free carbon dioxide and the three forms of alkalinity, stating that: "For waters having temperatures of 15–25 C, dissolved solids concentrations of 500 ppm or less and pH values below 10.0, all corrections may be neglected and the diagrams may be used in the form given [in his article]." He also suggested that: "For waters outside these limits, the values of the constants may be corrected for temperature and salt concentrations and the corrected values substituted directly in the equations."

Meanwhile, Amorosi and McDermet (4), in a study of the distribution of carbon dioxide between steam and water in deaerating feedwater heaters, developed a method for calculating the pH that a water would have at higher temperatures upon the basis of a determination of the pH value at 25 C and the total carbon dioxide, combined and free, in the water. This method was based upon suggestions by McKinney (5). Later, in a 1945 study of corrosion prevention in cooling tower systems, Powell, Bacon, and Lill (6) used the Amorosi and McDermet method to compute the pH at higher temperatures. Their curves were later revised by Powell, Bacon, and Knoedler (7) on the basis of newer and presumably more accurate ionization constants.

In 1946 Langelier presented discussions of chemical equilibria (8) and the effect of temperature on pH (9).

In the first of these articles he indicated that, when examples were investigated for higher temperatures, he found temperature effects that could hardly have been suspected prior to working out the temperature-alkalinity relationships of pH in carbonate solutions. In the second, he presented a method, largely graphical, for converting room temperature pH values to the actual values at other temperatures. For use of this method, a separate set of graphs must be constructed for each temperature at which it is desired to predict the pH value.

A comparison of the results obtained by Langelier with the revised graphs prepared by Powell et al., revealed some discrepancies, especially at higher temperatures. Generally, Powell et al. obtained a greater lowering at the higher temperatures than did Langelier. A study by Green (10) presents a comparison between experimental results and those calculated by Powell et al. and Langelier. The experimental results agreed better with Langelier's values—that is, curves plotted from the experimental values parallel the curves plotted from Langelier's values more closely than those plotted from Powell's. That the experimental results do not agree more closely with the calculated values is not surprising, since the ideal conditions assumed by Langelier and also by Amorosi and McDermet are difficult to attain in the laboratory. Furthermore, there is some uncertainty whether the pH measurements at higher temperatures are absolutely accurate.

Calculation of Effect of Temperature on pH

The method described below for the calculation of the effect of temperature on pH was developed in a search for a means that would be as accurate as the Langelier method but flexible enough to permit calculation regardless of the initial and final temperature, and which, also, would involve only ordinary arithmetical procedures.

The limiting conditions that were assumed have already been stated by McKinney (5) and Langelier (9): There shall be no loss of carbon dioxide by volatilization, no change in concentration caused by evaporation or precipitation, and salts of weak acids, other than carbonic, shall be absent. Under these ideal conditions it should be possible to calculate the pH value at other temperatures, using those elements in the system that remain constant regardless of temperature change—that is, the total alkalinity and the total (combined and free) carbon dioxide content.

Total alkalinity can be determined by the usual titration; and for the determination of total carbon dioxide a variety of methods are available, including the direct titration described by Amorosi and McDermet (4), the evolution method given in *Standard Methods* (11), and calculation from the concentrations of H_2CO_3, HCO_3^-, and CO_3^{--} found by use of Langelier's and DeMartini's equations or the charts or nomographs solving these equations. For the low alkalinities occurring in many natural waters and in most lime-softened waters, however, the evaluation of total carbon dioxide from total alkalinity and the pH of the water, as outlined below, is preferable, because it provides the accuracy needed in the calculations.

Development of General Equation

In developing a general equation for calculating total carbon dioxide and,

TABLE 1—*Values of* r, *in the Equation* $r = \frac{\text{Total } CO_2}{(\text{Alky} - \text{ppm } [OH^-])}$,

pH	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°
6.0	4.197	3.768	3.459	3.191	2.999	2.854	2.746	2.670	2.619	2.592	2.585
6.1	3.515	3.174	2.929	2.715	2.563	2.448	2.362	2.301	2.261	2.399	2.234
6.2	2.973	2.702	2.507	2.338	2.217	2.126	2.057	2.009	1.977	1.960	1.956
6.3	2.542	2.327	2.172	2.038	1.942	1.869	1.815	1.786	1.751	1.738	1.734
6.4	2.200	2.030	1.907	1.800	1.724	1.666	1.623	1.592	1.572	1.561	1.558
6.5	1.929	1.794	1.696	1.611	1.550	1.504	1.470	1.446	1.430	1.421	1.419
6.6	1.713	1.606	1.528	1.461	1.412	1.376	1.349	1.330	1.317	1.310	1.308
6.7	1.542	1.456	1.395	1.341	1.303	1.274	1.252	1.237	1.231	1.221	1.220
6.8	1.406	1.338	1.289	1.247	1.216	1.193	1.176	1.163	1.155	1.151	1.150
6.9	1.298	1.244	1.205	1.171	1.147	1.128	1.115	1.105	1.099	1.095	1.094
7.0	1.212	1.169	1.138	1.111	1.092	1.077	1.066	1.059	1.053	1.051	1.050
7.1	1.143	1.109	1.085	1.063	1.048	1.036	1.028	1.022	1.018	1.015	1.015
7.2	1.092	1.062	1.042	1.025	1.013	1.004	0.997	0.992	0.989	0.987	0.987
7.3	1.046	1.024	1.009	0.995	0.986	0.977	0.973	0.969	0.966	0.965	0.964
7.4	1.012	0.994	0.982	0.971	0.964	0.958	0.953	0.950	0.949	0.947	0.946
7.5	0.984	0.971	0.961	0.952	0.946	0.941	0.938	0.935	0.933	0.932	0.932
7.6	0.963	0.952	0.944	0.937	0.932	0.928	0.925	0.923	0.922	0.921	0.921
7.7	0.945	0.937	0.930	0.925	0.921	0.913	0.915	0.913	0.913	0.911	0.911
7.8	0.931	0.924	0.919	0.914	0.911	0.909	0.907	0.905	0.904	0.904	0.903
7.9	0.920	0.915	0.910	0.907	0.904	0.902	0.900	0.899	0.898	0.897	0.897
8.0	0.911	0.907	0.903	0.900	0.898	0.896	0.894	0.893	0.892	0.892	0.891
8.1	0.904	0.900	0.897	0.894	0.892	0.891	0.889	0.888	0.887	0.887	0.886
8.2	0.898	0.894	0.892	0.890	0.888	0.886	0.885	0.884	0.883	0.882	0.882
8.3	0.893	0.890	0.887	0.885	0.883	0.882	0.881	0.879	0.878	0.878	0.877
8.4	0.888	0.886	0.883	0.881	0.879	0.878	0.876	0.875	0.874	0.873	0.872
8.5	0.884	0.882	0.879	0.877	0.875	0.874	0.872	0.871	0.869	0.868	0.867
8.6	0.880	0.878	0.876	0.872	0.871	0.869	0.867	0.866	0.864	0.863	0.862
8.7	0.877	0.874	0.871	0.869	0.866	0.864	0.862	0.860	0.858	0.857	0.856
8.8	0.873	0.870	0.866	0.864	0.861	0.859	0.857	0.854	0.852	0.850	0.848
8.9	0.868	0.865	0.862	0.859	0.855	0.852	0.849	0.846	0.844	0.842	0.840
9.0	0.864	0.860	0.856	0.852	0.848	0.844	0.841	0.837	0.834	0.832	0.830
9.1	0.858	0.854	0.849	0.844	0.840	0.835	0.831	0.827	0.823	0.821	0.818
9.2	0.852	0.846	0.841	0.835	0.830	0.824	0.820	0.815	0.811	0.807	0.804
9.3	0.844	0.838	0.831	0.825	0.818	0.812	0.806	0.818	0.796	0.792	0.788
9.4	0.835	0.828	0.820	0.812	0.804	0.797	0.791	0.784	0.778	0.774	0.770
9.5	0.824	0.815	0.806	0.797	0.788	0.780	0.773	0.765	0.759	0.754	0.749
9.6	0.811	0.801	0.790	0.780	0.770	0.760	0.753	0.745	0.738	0.732	0.727
9.7	0.797	0.785	0.773	0.759	0.750	0.740	0.731	0.722	0.715	0.709	0.703
9.8	0.780	0.767	0.753	0.740	0.728	0.717	0.707	0.698	0.690	0.684	0.678
9.9	0.761	0.746	0.731	0.717	0.704	0.692	0.683	0.673	0.665	0.659	0.653
10.0	0.739	0.724	0.707	0.693	0.679	0.667	0.657	0.647	0.640	0.634	0.628
10.1	0.718	0.700	0.683	0.668	0.654	0.642	0.632	0.622	0.602	0.609	0.604
10.2	0.692	0.675	0.657	0.642	0.629	0.617	0.608	0.598	0.591	0.586	0.581
10.3	0.667	0.649	0.632	0.618	0.605	0.593	0.585	0.576	0.573	0.564	0.560
10.4	0.642	0.624	0.608	0.594	0.582	0.571	0.563	0.555	0.549	0.545	0.541
10.5	0.617	0.600	0.585	0.572	0.561	0.551	0.544	0.537	0.532	0.528	0.524
10.6	0.593	0.577	0.563	0.551	0.541	0.533	0.527	0.521	0.516	0.513	0.509
10.7	0.571	0.557	0.544	0.541	0.525	0.517	0.512	0.507	0.503	0.500	0.497
10.8	0.551	0.538	0.527	0.518	0.510	0.504	0.499	0.495	0.491	0.489	0.487
10.9	0.533	0.522	0.512	0.504	0.498	0.492	0.488	0.484	0.482	0.480	0.477
11.0	0.517	0.507	0.499	0.492	0.487	0.483	0.479	0.476	0.474	0.472	0.471
11.1	0.503	0.495	0.488	0.483	0.478	0.474	0.472	0.469	0.467	0.466	0.465
11.2	0.492	0.486	0.479	0.475	0.471	0.468	0.466	0.464	0.462	0.461	0.460
11.3	0.482	0.477	0.472	0.468	0.465	0.462	0.451	0.459	0.458	0.457	0.456
11.4	0.474	0.470	0.466	0.463	0.460	0.458	0.457	0.455	0.454	0.453	0.453
11.5	0.468	0.464	0.461	0.458	0.456	0.454	0.453	0.452	0.451	0.451	0.450
11.6	0.462	0.459	0.457	0.455	0.453	0.452	0.451	0.450	0.449	0.449	0.448
11.7	0.458	0.455	0.453	0.452	0.450	0.449	0.448	0.448	0.447	0.447	0.446
11.8	0.454	0.452	0.451	0.449	0.448	0.447	0.447	0.446	0.446	0.446	0.445
11.9	0.451	0.450	0.448	0.447	0.447	0.446	0.445	0.445	0.445	0.444	0.444
12.0	0.449	0.448	0.447	0.446	0.445	0.445	0.444	0.444	0.444	0.444	0.443

for the pH Range of 6.0–12.0 and the Temperature Range of 0–100 C

pH	55°	60°	65°	70°	75°	80°	85°	90°	95°	100°	pH
6.0	2.599	2.631	2.684	2.757	2.940	2.971	3.118	3.296	3.507	3.761	6.0
6.1	2.245	2.271	2.313	2.376	2.446	2.541	2.657	2.799	2.967	3.168	6.1
6.2	1.964	1.985	2.018	2.064	2.124	2.199	2.292	2.404	2.538	2.698	6.2
6.3	1.741	1.755	1.784	1.820	1.868	1.928	2.001	2.091	2.196	2.324	6.3
6.4	1.564	1.577	1.598	1.627	1.665	1.712	1.771	1.841	1.926	2.027	6.4
6.5	1.424	1.434	1.451	1.473	1.504	1.541	1.588	1.644	1.711	1.791	6.5
6.6	1.312	1.320	1.333	1.352	1.377	1.405	1.442	1.487	1.540	1.604	6.6
6.7	1.223	1.229	1.240	1.254	1.273	1.297	1.326	1.362	1.404	1.455	6.7
6.8	1.152	1.157	1.166	1.177	1.192	1.211	1.234	1.263	1.296	1.336	6.8
6.9	1.096	1.100	1.107	1.116	1.128	1.143	1.161	1.184	1.210	1.242	6.9
7.0	1.051	1.055	1.060	1.067	1.077	1.088	1.103	1.121	1.142	1.167	7.0
7.1	1.016	1.018	1.023	1.028	1.036	1.045	1.057	1.071	1.088	1.108	7.1
7.2	0.988	0.990	0.993	0.997	1.003	1.011	1.020	1.031	1.045	1.061	7.2
7.3	0.965	0.967	0.969	0.973	0.977	0.983	0.991	1.000	1.010	1.023	7.3
7.4	0.947	0.948	0.950	0.953	0.957	0.962	0.967	0.974	0.983	0.993	7.4
7.5	0.932	0.933	0.935	0.937	0.940	0.944	0.949	0.954	0.961	0.969	7.5
7.6	0.921	0.921	0.923	0.925	0.927	0.930	0.934	0.938	0.943	0.950	7.6
7.7	0.911	0.912	0.913	0.914	0.916	0.918	0.921	0.925	0.929	0.934	7.7
7.8	0.903	0.904	0.905	0.905	0.907	0.909	0.911	0.914	0.918	0.922	7.8
7.9	0.897	0.897	0.898	0.898	0.900	0.901	0.903	0.905	0.908	0.911	7.9
8.0	0.891	0.891	0.892	0.892	0.893	0.894	0.896	0.898	0.900	0.903	8.0
8.1	0.886	0.886	0.886	0.887	0.887	0.888	0.890	0.891	0.893	0.895	8.1
8.2	0.881	0.881	0.881	0.882	0.882	0.883	0.884	0.885	0.888	0.889	8.2
8.3	0.877	0.876	0.876	0.877	0.877	0.878	0.878	0.879	0.881	0.882	8.3
8.4	0.872	0.872	0.871	0.871	0.872	0.872	0.873	0.874	0.875	0.876	8.4
8.5	0.867	0.866	0.866	0.866	0.866	0.867	0.867	0.868	0.869	0.870	8.5
8.6	0.861	0.860	0.860	0.860	0.860	0.860	0.861	0.862	0.863	0.864	8.6
8.7	0.854	0.854	0.853	0.853	0.853	0.853	0.854	0.855	0.856	0.858	8.7
8.8	0.846	0.846	0.845	0.845	0.845	0.845	0.846	0.846	0.848	0.849	8.8
8.9	0.838	0.837	0.836	0.835	0.835	0.835	0.836	0.837	0.838	0.840	8.9
9.0	0.828	0.826	0.825	0.824	0.824	0.824	0.825	0.826	0.827	0.829	9.0
9.1	0.815	0.813	0.812	0.811	0.811	0.811	0.812	0.813	0.815	0.817	9.1
9.2	0.801	0.799	0.797	0.796	0.796	0.796	0.797	0.798	0.800	0.802	9.2
9.3	0.785	0.782	0.780	0.779	0.779	0.779	0.780	0.781	0.783	0.786	9.3
9.4	0.766	0.763	0.761	0.760	0.760	0.760	0.761	0.762	0.764	0.767	9.4
9.5	0.745	0.742	0.740	0.739	0.738	0.738	0.739	0.741	0.743	0.746	9.5
9.6	0.723	0.719	0.717	0.716	0.715	0.715	0.716	0.718	0.721	0.724	9.6
9.7	0.699	0.695	0.693	0.691	0.691	0.691	0.692	0.694	0.696	0.700	9.7
9.8	0.674	0.670	0.668	0.666	0.665	0.666	0.667	0.669	0.671	0.675	9.8
9.9	0.648	0.645	0.642	0.641	0.640	0.640	0.641	0.643	0.646	0.649	9.9
10.0	0.623	0.620	0.617	0.616	0.615	0.616	0.617	0.618	0.621	0.624	10.0
10.1	0.599	0.596	0.594	0.592	0.592	0.592	0.593	0.595	0.597	0.600	10.1
10.2	0.577	0.574	0.571	0.570	0.570	0.570	0.571	0.572	0.575	0.580	10.2
10.3	0.556	0.553	0.551	0.550	0.550	0.550	0.551	0.552	0.554	0.557	10.3
10.4	0.537	0.535	0.533	0.532	0.532	0.532	0.533	0.533	0.536	0.538	10.4
10.5	0.521	0.519	0.517	0.517	0.516	0.516	0.517	0.518	0.520	0.522	10.5
10.6	0.507	0.505	0.504	0.503	0.503	0.503	0.503	0.504	0.506	0.507	10.6
10.7	0.495	0.493	0.493	0.492	0.491	0.492	0.492	0.493	0.494	0.495	10.7
10.8	0.485	0.484	0.483	0.482	0.482	0.482	0.482	0.483	0.484	0.485	10.8
10.9	0.476	0.475	0.475	0.474	0.474	0.474	0.474	0.475	0.476	0.477	10.9
11.0	0.469	0.469	0.468	0.468	0.467	0.467	0.468	0.468	0.469	0.470	11.0
11.1	0.464	0.463	0.462	0.462	0.462	0.462	0.462	0.463	0.463	0.464	11.1
11.2	0.459	0.459	0.458	0.458	0.458	0.458	0.458	0.458	0.459	0.459	11.2
11.3	0.455	0.455	0.454	0.454	0.454	0.454	0.454	0.455	0.455	0.455	11.3
11.4	0.452	0.452	0.452	0.451	0.451	0.451	0.452	0.452	0.452	0.452	11.4
11.5	0.450	0.449	0.449	0.449	0.449	0.449	0.449	0.449	0.450	0.450	11.5
11.6	0.448	0.448	0.447	0.447	0.447	0.447	0.447	0.448	0.448	0.448	11.6
11.7	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	11.7
11.8	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	0.445	11.8
11.9	0.444	0.444	0.444	0.444	0.444	0.444	0.444	0.444	0.444	0.444	11.9
12.0	0.443	0.443	0.443	0.443	0.443	0.443	0.443	0.443	0.443	0.443	12.0

TABLE 2—*Values for Hydroxide Alkalinity* ([OH^-] as ppm $CaCO_3$)

pH	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°
6.0											
6.1											
6.2											
6.3											0.006
6.4										0.005	0.007
6.5									0.005	0.006	0.009
6.6									0.006	0.008	0.011
6.7								0.005	0.007	0.010	0.014
6.8							0.005	0.007	0.009	0.013	0.017
6.9							0.006	0.008	0.012	0.016	0.022
7.0						0.005	0.007	0.010	0.015	0.020	0.027
7.1						0.006	0.009	0.013	0.018	0.025	0.034
7.2					0.005	0.008	0.012	0.017	0.023	0.032	0.043
7.3				0.005	0.007	0.010	0.015	0.021	0.029	0.040	0.055
7.4				0.006	0.009	0.013	0.018	0.026	0.037	0.050	0.069
7.5			0.005	0.007	0.011	0.016	0.023	0.033	0.046	0.064	0.087
7.6			0.006	0.009	0.014	0.020	0.029	0.042	0.058	0.080	0.109
7.7		0.005	0.007	0.011	0.017	0.025	0.037	0.052	0.073	0.101	0.137
7.8		0.006	0.009	0.014	0.021	0.032	0.046	0.066	0.092	0.127	0.173
7.9	0.005	0.007	0.012	0.018	0.027	0.040	0.058	0.083	0.116	0.160	0.217
8.0	0.006	0.009	0.015	0.023	0.034	0.050	0.073	0.104	0.146	0.201	0.274
8.1	0.007	0.012	0.018	0.028	0.043	0.063	0.092	0.132	0.184	0.253	0.345
8.2	0.009	0.015	0.023	0.036	0.054	0.080	0.116	0.166	0.231	0.318	0.434
8.3	0.011	0.018	0.029	0.045	0.068	0.101	0.147	0.208	0.291	0.401	0.546
8.4	0.014	0.023	0.036	0.057	0.085	0.127	0.185	0.262	0.367	0.505	0.688
8.5	0.018	0.029	0.046	0.071	0.108	0.159	0.232	0.330	0.462	0.635	0.866
8.6	0.023	0.037	0.058	0.090	0.135	0.201	0.292	0.416	0.581	0.800	1.090
8.7	0.028	0.046	0.073	0.113	0.171	0.252	0.371	0.524	0.731	1.006	1.372
8.8	0.036	0.058	0.092	0.142	0.215	0.318	0.463	0.659	0.921	1.268	1.726
8.9	0.045	0.073	0.116	0.179	0.270	0.400	0.583	0.830	1.159	1.596	2.174
9.0	0.057	0.092	0.146	0.225	0.340	0.504	0.735	1.045	1.460	2.009	2.737
9.1	0.072	0.116	0.184	0.284	0.428	0.635	0.925	1.315	1.837	2.529	3.446
9.2	0.090	0.146	0.231	0.357	0.539	0.799	1.164	1.655	2.313	3.184	4.338
9.3	0.114	0.184	0.291	0.449	0.679	1.006	1.466	2.084	2.912	4.009	5.461
9.4	0.143	0.232	0.367	0.566	0.855	1.266	1.845	2.624	3.666	5.047	6.875
9.5	0.180	0.292	0.462	0.712	1.076	1.594	2.323	3.303	4.615	6.350	8.655
9.6	0.227	0.367	0.581	0.897	1.355	2.007	2.924	4.158	5.811	7.998	10.90
9.7	0.285	0.463	0.732	1.129	1.705	2.521	3.706	5.235	7.315	10.06	13.72
9.8	0.359	0.582	0.921	1.421	2.147	3.180	4.634	6.591	9.209	12.68	17.26
9.9	0.452	0.733	1.160	1.789	2.703	4.004	5.835	8.296	11.59	15.96	21.74
10.0	0.570	0.923	1.460	2.253	3.403	5.040	7.345	10.45	14.60	20.09	27.37
10.1	0.717	1.162	1.838	2.836	4.284	6.345	9.247	13.15	18.37	25.29	34.46
10.2	0.903	1.463	2.314	3.570	5.393	7.988	11.64	16.55	23.13	31.84	43.38
10.3	1.136	1.842	2.913	4.494	6.789	10.06	14.66	20.84	29.12	40.09	54.61
10.4	1.431	2.319	3.667	5.658	8.547	12.66	18.45	26.24	36.66	50.47	68.75
10.5	1.801	2.919	4.617	7.123	10.76	15.94	23.23	33.03	46.15	63.50	86.55
10.6	2.267	3.675	5.813	8.968	13.55	20.07	29.24	41.58	58.11	79.98	109.0
10.7	2.854	4.626	7.317	11.29	17.05	25.21	37.06	52.35	73.15	100.6	137.2
10.8	3.593	5.824	9.212	14.21	21.47	31.80	46.34	65.91	92.09	126.8	172.6
10.9	4.524	7.332	11.60	17.89	27.03	40.04	58.35	82.97	115.9	159.6	217.4
11.0	5.695	9.230	14.60	22.53	34.02	50.40	73.45	104.5	146.0	200.9	273.7
11.1	7.170	11.62	18.38	28.36	42.84	63.45	92.47	131.5	183.7	252.9	344.6
11.2	9.026	14.63	23.14	35.70	53.93	79.88	116.4	165.5	231.3	318.4	433.8
11.3	11.36	18.42	29.13	44.94	67.89	100.6	146.6	208.4	291.2	400.9	546.1
11.4	14.31	23.19	36.67	56.58	85.47	126.6	184.5	262.4	366.6	504.7	687.5
11.5	18.01	29.19	46.17	71.23	107.6	159.4	232.3	330.3	461.5	635.0	865.5
11.6	22.67	36.75	58.13	89.68	135.5	200.7	292.4	415.8	581.1	799.8	1,090
11.7	28.54	46.26	73.17	112.9	170.5	252.1	370.6	523.5	731.5	1,006	1,372
11.8	35.93	58.24	92.12	142.1	214.7	318.0	463.4	659.1	920.9	1,268	1,726
11.9	45.25	73.32	116.0	178.9	270.3	400.4	583.5	829.7	1,159	1,596	2,174
12.0	56.95	92.30	146.0	225.3	340.2	504.0	734.5	1,045	1,460	2,009	2,737

for the pH Range of 6.0–12.0 and the Temperature Range of 0–100 C

pH	55°	60°	65°	70°	75°	80°	85°	90°	95°	100°	pH
6.0		0.005	0.006	0.008	0.010	0.013	0.016	0.019	0.023	0.028	6.0
6.1	0.005	0.006	0.008	0.010	0.013	0.016	0.020	0.024	0.029	0.035	6.1
6.2	0.006	0.008	0.010	0.013	0.016	0.020	0.025	0.031	0.037	0.044	6.2
6.3	0.007	0.010	0.013	0.016	0.020	0.025	0.031	0.038	0.047	0.056	6.3
6.4	0.009	0.012	0.016	0.020	0.026	0.032	0.040	0.048	0.059	0.070	6.4
6.5	0.012	0.015	0.020	0.025	0.032	0.040	0.050	0.061	0.074	0.088	6.5
6.6	0.015	0.019	0.025	0.032	0.040	0.051	0.063	0.077	0.093	0.111	6.6
6.7	0.018	0.025	0.031	0.040	0.051	0.064	0.079	0.096	0.117	0.140	6.7
6.8	0.023	0.030	0.040	0.051	0.064	0.080	0.099	0.121	0.147	0.176	6.8
6.9	0.029	0.038	0.050	0.064	0.081	0.101	0.125	0.153	0.185	0.222	6.9
7.0	0.036	0.048	0.063	0.080	0.102	0.127	0.157	0.192	0.233	0.280	7.0
7.1	0.046	0.06[illegible]	0.079	0.101	0.128	0.160	0.198	0.242	0.294	0.352	7.1
7.2	0.058	0.076	0.099	0.127	0.161	0.202	0.249	0.305	0.370	0.443	7.2
7.3	0.073	0.096	0.125	0.160	0.203	0.254	0.314	0.384	0.465	0.558	7.3
7.4	0.091	0.121	0.157	0.202	0.255	0.319	0.395	0.484	0.586	0.702	7.4
7.5	0.115	0.152	0.198	0.254	0.322	0.402	0.498	0.609	0.737	0.884	7.5
7.6	0.145	0.191	0.249	0.320	0.405	0.506	0.626	0.766	0.928	1.113	7.6
7.7	0.183	0.246	0.314	0.403	0.510	0.63[illegible]	0.789	0.965	1.169	1.401	7.7
7.8	0.230	0.303	0.395	0.507	0.642	0.803	0.993	1.215	1.471	1.764	7.8
7.9	0.290	0.382	0.498	0.638	0.808	1.010	1.250	1.529	1.852	2.221	7.9
8.0	0.365	0.481	0.629	0.803	1.017	1.272	1.574	1.925	2.332	2.796	8.0
8.1	0.459	0.605	0.789	1.011	1.280	1.601	1.981	2.423	2.935	3.520	8.1
8.2	0.578	0.762	0.993	1.273	1.612	2.016	2.494	3.051	3.695	4.431	8.2
8.3	0.728	0.959	1.250	1.603	2.029	2.538	3.139	3.841	4.652	5.578	8.3
8.4	0.916	1.208	1.574	2.017	2.554	3.195	3.953	4.835	5.857	7.023	8.4
8.5	1.154	1.520	1.981	2.540	3.216	4.022	4.976	6.087	7.373	8.841	8.5
8.6	1.453	1.914	2.494	3.197	4.048	5.064	6.264	7.663	9.282	11.13	8.6
8.7	1.829	2.461	3.140	4.025	5.096	6.375	7.886	9.647	11.69	14.01	8.7
8.8	2.302	3.033	3.953	5.068	6.416	8.025	9.928	12.15	14.71	17.64	8.8
8.9	2.898	3.818	4.977	6.380	8.078	10.10	12.50	15.29	18.52	22.21	8.9
9.0	3.649	4.807	6.286	8.032	10.17	12.72	15.74	19.25	23.32	27.96	9.0
9.1	4.593	6.052	7.888	10.11	12.80	16.01	19.81	24.23	29.35	35.20	9.1
9.2	5.783	7.619	9.930	12.73	16.12	20.16	24.94	30.51	36.95	44.31	9.2
9.3	7.280	9.591	12.50	16.03	20.29	25.38	31.39	38.41	46.52	55.78	9.3
9.4	9.165	12.08	15.74	20.17	25.54	31.95	39.53	48.35	58.57	70.23	9.4
9.5	11.54	15.20	19.81	25.40	32.16	40.22	49.76	60.87	73.73	88.41	9.5
9.6	14.53	19.14	24.94	31.97	40.48	50.64	62.64	76.63	92.82	111.3	9.6
9.7	18.29	24.61	31.40	40.25	50.96	63.75	78.86	96.47	116.9	140.1	9.7
9.8	23.02	30.33	39.53	50.68	64.16	80.25	99.28	121.5	147.1	176.4	9.8
9.9	28.98	38.18	49.77	63.80	80.78	101.0	125.0	152.9	185.2	222.0	9.9
10.0	36.49	48.07	62.86	80.32	101.7	127.2	157.4	192.5	233.2	279.6	10.0
10.1	45.93	60.52	78.88	101.1	128.0	160.1	198.1	242.3	293.5	352.0	10.1
10.2	57.83	76.19	99.30	127.3	161.2	201.6	249.4	305.1	369.5	443.1	10.2
10.3	72.80	95.91	125.0	160.3	202.9	253.8	313.9	384.1	465.2	557.8	10.3
10.4	91.65	120.8	157.4	201.7	255.4	319.5	395.3	483.5	585.7	702.3	10.4
10.5	115.4	152.0	198.1	254.0	321.6	402.2	497.6	608.7	737.3	884.1	10.5
10.6	145.3	191.4	249.4	319.7	404.8	506.4	626.4	766.3	928.2	1,113	10.6
10.7	182.9	246.1	314.0	402.5	509.6	637.5	788.6	964.7	1,169	1,401	10.7
10.8	230.2	303.3	395.3	506.8	641.6	802.5	992.8	1,215	1,471	1,764	10.8
10.9	289.8	381.8	497.7	638.0	807.8	1,010	1,250	1,529	1,852	2,221	10.9
11.0	364.9	480.7	628.6	803.2	1,017	1,272	1,574	1,925	2,332	2,796	11.0
11.1	459.3	605.2	788.8	1,011	1,280	1,601	1,981	2,423	2,935	3,520	11.1
11.2	578.3	761.9	993.0	1,273	1,612	2,016	2,494	3,051	3,695	4,431	11.2
11.3	728.0	959.1	1,250	1,603	2,029	2,538	3,139	3,841	4,652	5,578	11.3
11.4	916.5	1,208	1,574	2,017	2,554	3,195	3,953	4,835	5,857	7,023	11.4
11.5	1,154	1,520	1,981	2,540	3,216	4,022	4,976	6,087	7,373	8,841	11.5
11.6	1,453	1,914	2,494	3,197	4,048	5,064	6,264	7,663	9,282	11,130	11.6
11.7	1,829	2,461	3,140	4,025	5,096	6,375	7,886	9,647	11,690	14,010	11.7
11.8	2,302	3,033	3,953	5,068	6,416	8,025	9,928	12,150	14,710	17,640	11.8
11.8	2,898	3,818	4,977	6,380	8,078	10,100	12,500	15,290	18,520	22,210	11.9
12.0	3,649	4,807	6,286	8,032	10,170	12,720	15,740	19,250	23,320	27,960	12.0

from this, the pH at the new temperature at which the total carbon dioxide is unchanged, basic equations for dissociation constants are used:

$$K_1 = \frac{[H^+] \times [HCO_3^-]}{[H_2CO_3]},$$

or

$$[H_2CO_3] = \frac{[H^+] \times [HCO_3^-]}{K_1} \quad ..[1]$$

$$K_2 = \frac{[H^+] \times [CO_3^{--}]}{[HCO_3^-]},$$

or

$$[CO_3^{--}] = \frac{K_2 \times [HCO_3^-]}{[H^+]} \quad ..[2]$$

$$K_w = [H^+] \times [OH^-],$$

or

$$[OH^-] = \frac{K_w}{[H^+]} \quad ......[3]$$

and also the equation for electric neutrality:

$$[H^+] + [Alky] = [HCO_3^-] + 2[CO_3^{--}] + [OH^-] \quad ..[4]$$

If the total carbon dioxide content, combined and free, is designated as C:

$$C = [H_2CO_3] + [HCO_3^-] + [CO_3^{--}] \quad ..[5]$$

In these equations, brackets represent concentrations in mols per liter and [Alky] represents equivalents of titratable base. Since there is concern only with relatively small changes in pH, the effect of ionic strength can be ignored.

Substituting the values for $[H_2CO_3]$ and $[CO_3^{--}]$ from Eq. 1 and 2 into Eq. 5:

$$C = \left(\frac{[H^+]}{K_1} + \frac{K_2}{[H^+]} + 1\right) \times [HCO_3^-] \quad ..[6]$$

If the $[H^+]$ is dropped from Eq. 4 as insignificant for the present purpose in the pH range of 6.0 to 12.0, then, from Eq. 2 and 4:

$$[HCO_3^-] = \left([Alky] - \frac{K_w}{[H^+]}\right) \times \left(\frac{[H^+]}{[H^+] + 2K_2}\right) \quad ..[7]$$

and substitution of this value for $[HCO_3^-]$ in Eq. 6, will demonstrate that:

$$C = \left(\frac{[H^+]}{K_1} + \frac{K_2}{[H^+]} + 1\right) \times \left(\frac{[H^+]}{[H^+] + 2K_2}\right) \times \left([Alky] - \frac{K_w}{[H^+]}\right) \quad ..[8]$$

From Eq. 8 it can be seen that the total carbon dioxide content, C, can be determined from the total alkalinity, the pH value, and the dissociation constants for the temperature at which the pH value is determined. Since it has been assumed that, in a closed system, the total carbon dioxide content and the alkalinity remain unchanged, it should be possible to calculate the pH value for the water in questions at any other temperature by use of Eq. 8. This leads, however, to a cubic equation, unsuited to routine use or to ready nomographic solution. It is necessary, therefore, to resort to an indirect method of solution.

By rearranging Eq. 8 and substituting $[OH^-]$ for the term

$$\frac{K_w}{[H^+]},$$

the following expression is obtained:

$$\frac{C}{[Alky] - [OH^-]}$$

$$= \left(\frac{[H^+]}{K_1} + \frac{K_2}{[H^+]} + 1\right) \times \left(\frac{[H^+]}{[H^+] + 2K_2}\right) \quad [9]$$

If the ratio of the total carbon dioxide content, C, to the nonhydroxide alkalinity is expressed as r, then:

$$r = \frac{C}{[\text{Alky}] - [OH^-]} \quad [10]$$

and also:

$$r = \left(\frac{[H^+]}{K_1} + \frac{K_2}{[H^+]} + 1\right) \times \left(\frac{[H^+]}{[H^+] + 2K_2}\right) \quad [11]$$

Thus it can be seen that the ratio of the total carbon dioxide content of a water to the base with which it is, at least in part, combined, is a constant at any one temperature and pH value; and this constant is independent of the individual values of C and the nonhydroxide alkalinity. Also, since the ionization constants for the various temperatures are known, the numerical values of r can be computed for any value of pH and any temperature. Conversely, if the pH, total alkalinity, and temperature are known, the total carbon dioxide content, C, can be calculated when the value for r has been determined for that pH value and temperature. Furthermore, if the values of r have been computed for the temperature and the approximate pH range at which it is desired to predict the pH value, it is possible, by interpolation, to determine, at the desired temperature, the pH value at which the total carbon dioxide content is the same as that calculated for the water at the temperature of the original pH determination.

Values of r for the pH range of 6.0 to 12.0 in steps of 0.1 pH unit, and in the temperature range of 0 to 100 C, in steps of 5 C, are given in Table 1. In Table 2, values for the hydroxide ion concentration or $[OH^-]$, as ppm $CaCO_3$, are given for the same pH and temperature ranges, so that the nonhydroxide alkalinity can be quickly found. Using the values of r as given in Table 1, total carbon dioxide content, C, will be determined as ppm. If it is desired to work in terms of mols per liter, the values for ppm $[OH^-]$ should be divided by 50,000 and the values of r, by 0.88.

Procedure

To predict the pH value at another temperature, first determine the total alkalinity and pH, noting the temperature of the pH determination. Using Table 2, determine the amount, in ppm, of $[OH^-]$ alkalinity at this pH value and temperature, interpolating if necessary, and then the nonhydroxide alkalinity or $(\text{Alky} - [OH^-])$. Then, using Table 1, find the value of r at this same pH value and temperature and calculate the total carbon dioxide content, C, by use of the equation:

$$C = r \times (\text{Alky} - [OH^-]) \quad [12]$$

Next, calculate the nonhydroxide alkalinity for several pH values at the desired temperature, in steps of 0.1 pH unit, and tabulate. Then tabulate from Table 1 the values of r at these pH values and calculate the values of C at the same values. Find the two values of C which lie just above and below the value found at the original temperature and, by interpolation, find the pH at which the value for C equals that found at the original temperature.

In the use of these tables, it should be remembered that increasing the temperature decreases the pH and de-

creasing the temperature increases the pH. Also, because of the buffering effect of carbonates and bicarbonates, the change in pH is greater for low alkalinities and less for high alkalinities. With a little practice it takes very few guesses to obtain the answer.

Examples

1. The alkalinity of a sample of water was 100 ppm and the pH at 25 C, 8.40. What would be the pH of this water at 75 C? From Table 2, the ppm $[OH^-] = 0.13$. $(\text{Alky} - [OH^-]) = 99.87$. From Table 1, $r = 0.878$. $C = 0.878 \times 99.87$ or 87.69. At 75 C, a pH range would be selected that is slightly lower than the pH at 25 C and a tabulation made as follows:

pH	ppm OH^-	(Alky $-[OH^-]$)	r	C
7.9	0.81	99.19	0.900	89.27
8.0	1.02	98.98	0.893	88.39
8.1	1.28	98.72	0.887	87.56

There is no need to proceed further with the tabulation, as the value of C lies between the values found at pH 8.0 and 8.1. By interpolating, it is found that, at a pH of 8.08, C equals the value of 87.69; therefore, at 75 C, the pH of this water would be 8.08.

2. The alkalinity of a water is 25 ppm and, at 25 C, the pH is 9.20. What will be the pH value at 50 C? At 25 C the ppm $[OH^-]$ is 0.799. The $(\text{Alky} - [OH^-]) = 24.20$; $r = 0.824$, and $C = 19.94$.

pH	ppm $[OH^-]$	(Alky $-[OH^-]$)	r	C
8.6	1.09	23.91	0.862	20.61
8.7	1.37	23.63	0.856	20.23
8.8	1.73	23.27	0.848	19.73

The pH at 50 C lies between 8.7 and 8.8. By interpolation, it is found that, at pH 8.76, $C = 19.94$ ppm.

3. The alkalinity of a softened water was 43 ppm and, at 17 C, the pH was 10.30. What would be the pH of this water at 180 F (82 C)? By interpolation it is found from Table 2 that the ppm $[OH^-] = 5.40$. Then $(\text{Alky} - [OH^-]) = 37.60$ ppm. By interpolation, $r = 0.612$; $C = 23.01$.

pH	ppm $[OH^-]$	(Alky $-[OH^-]$)	r	C
9.0	13.93	29.07	0.825	23.98
9.1	17.43	25.57	0.812	20.76

The pH value at 82 C is found to be 9.03. In this example it was necessary to find the values for ppm $[OH^-]$ and r at 17 C by interpolation.

Comparison of these results with those given in Langelier's tables (9) indicates substantial agreement. For Example 1, Langelier's result is 8.10, and for Example 2, he gives the value of 8.74. For Example 3, using the above method, this water would be found to have a pH of 10.13 at 25 C. By interpolating from Langelier's tables, the pH of 9.08 at 82 C was obtained.

pH Alkalinity Nomographs

In the current edition of *Standard Methods* (11), at the suggestion of Langelier (1), DeMartini (2), and Moore (3), the equations for the calculation of the free carbon dioxide, the bicarbonate, carbonate, and hydroxide alkalinities from total alkalinity, and the pH of the water were included. At the time these equations were first presented it was assumed that the effect of temperature was negligible or, at least in part, neutralized by the corrections for the effect of total solids and could be ignored if the pH was below 10.0. Further studies, however, revealed that temperature and ionic strength—especially

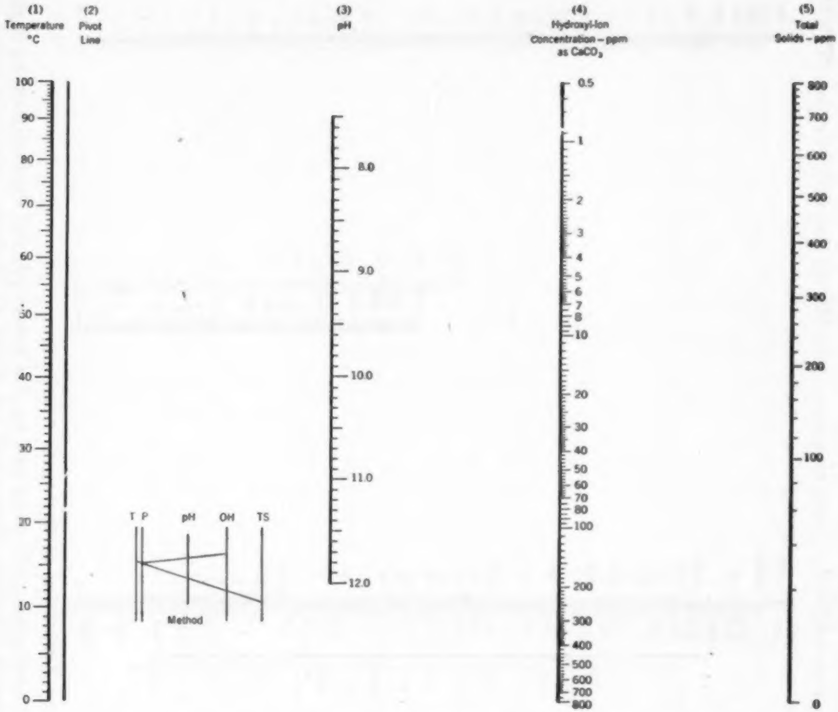


Fig. 1. Nomograph for the Evaluation of Hydroxyl-Ion Concentration

To use: (1) align temperature and total solids; (2) pivot on Line P *to proper pH, and read hydroxyl-ion concentration, as ppm $CaCO_3$, on OH scale (see Method).*

temperature—exert a considerable effect on the pH of a water and also upon the ion concentrations or the three forms of alkalinity and free carbon dioxide. Naturally, the saturation index is also affected.

The effect of temperature upon chemical reactions and ionic equilibria is well known. It should be the rule at any water treatment plant to make pH and alkalinity determinations immediately after the samples are taken. In treatment of a ground water at 12–15 C, the temperature of the samples when tested is usually not more than 15 C. To allow these samples to stand until they attain room temperature, approximately 25 C, before testing would invite such changes that the results obtained would not present a true picture of plant conditions. Likewise, to measure the pH of a water at 15 C and apply equations containing constants for 25 C will result in appreciable errors in the amounts of various ion concentrations or alkalinities.

It is probable that an increasing number of water softening plants will be installing pH recorders or indicators which will show the pH values

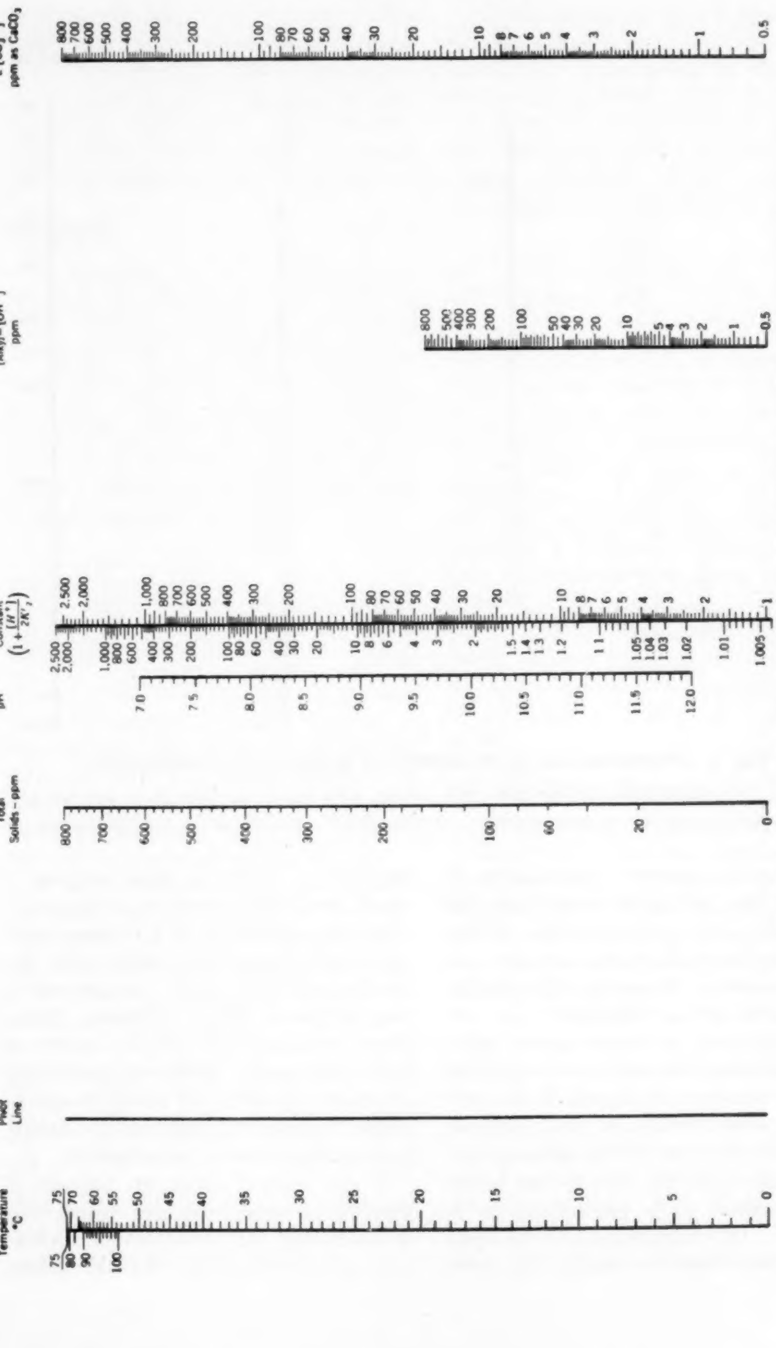


Fig. 2. Nomograph for Evaluation of Carbonate Alkalinity

To use: (1) align temperature of pH determination and total solids; (2) pivot on Line 2 to proper pH and read constant on Scale 5; (3) align constant on Scale 6 with value for nonhydroxide alkalinity (found with aid of Fig. 1) on Scale 7, and read carbonate alkalinity on Scale 8.

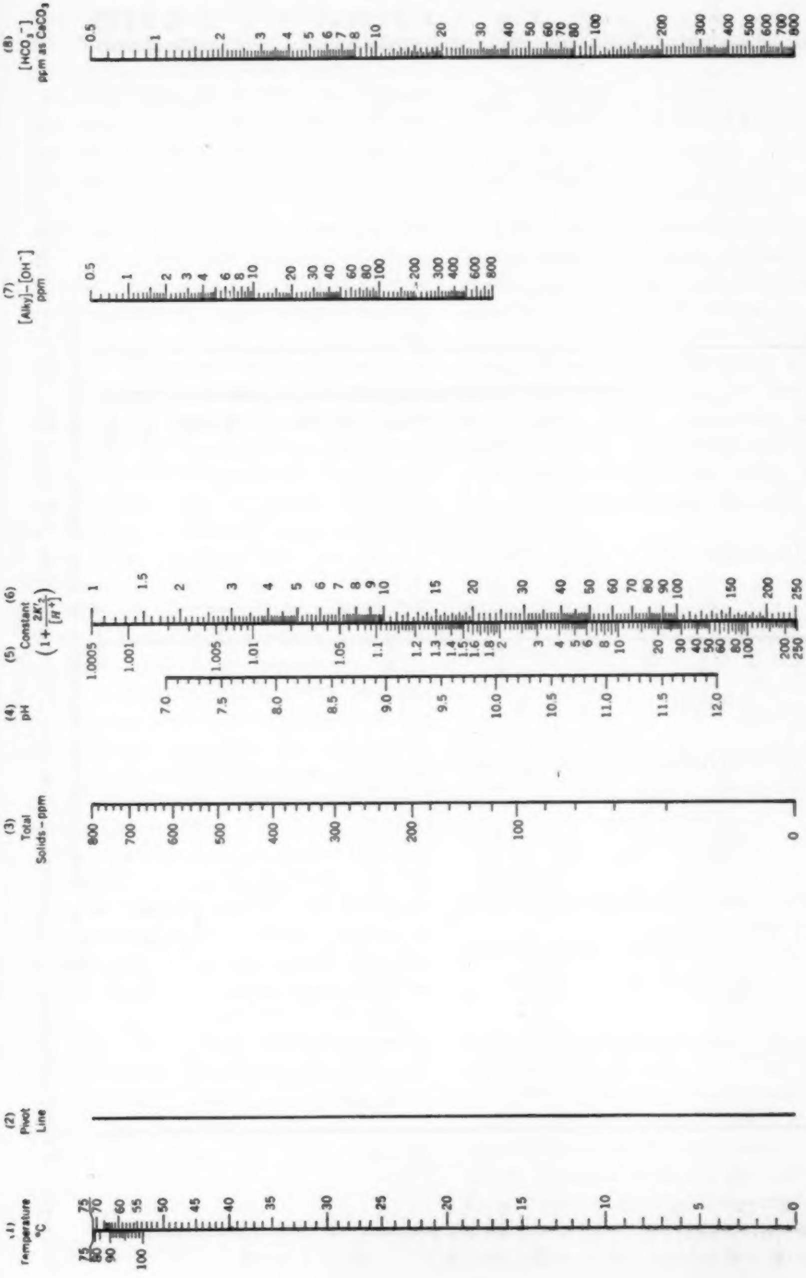


Fig. 3. Nomograph for Evaluation of Bicarbonate Alkalinity

To use: (1) align temperature of pH determination and total solids; (2) pivot on Line 2 to proper pH and read constant on Scale 5; (3) align constant on Scale 6 with nonhydroxide alkalinity (found with aid of Fig. 1) on Scale 7, and read bicarbonate alkalinity on Scale 8.

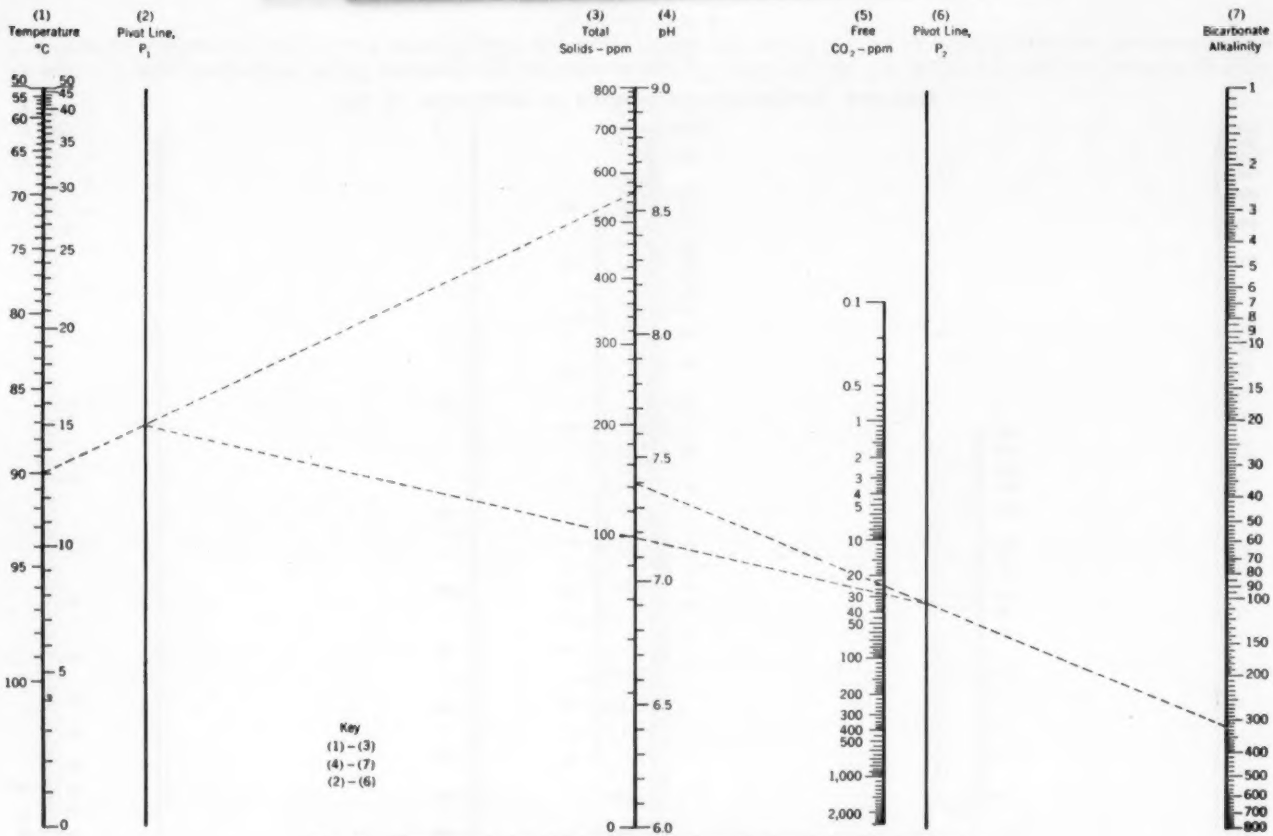


Fig. 4. Nomograph for Evaluation of Free Carbon Dioxide Content

Example: When temperature of pH determination was 13 C; total solids, 560 ppm; pH, 7.40; and alkalinity, 320 ppm—the free CO_2 content was 28 ppm.

that exist at various steps in the process at actual operating temperatures. For surface waters these temperatures can vary from 0 to 25 C or higher. The temperatures of most ground waters in the hard water territory in the Midwest are not much above 10 to 15 C. Some very confusing answers are obtained if the constants for 25 C are invariably applied to these waters. For example, a water from a sedimentation basin after lime softening might have a total solids content of 200 ppm, total alkalinity of 75 ppm and a pH of 11.3 at 12 C. On applying equations with constants corrected for temperature and ionic strength, the hydroxyl-ion concentration, as ppm $CaCO_3$, will be found to be 38 ppm, a perfectly reasonable answer. On applying the uncorrected constants for 25 C, however, the hydroxide alkalinity will be about 100 ppm, a value greater than the total alkalinity and thus impossible. This error is obvious, but in other less extreme cases the error is hidden and the operator will not realize that the figures are wrong until he attempts to obtain some correlation of these alkalinities with plant results.

The nomographs presented as Fig. 1–4 allow for corrections for the effects of temperatures of 0–100 C and of dissolved solids concentrations of 0–800 ppm. The corrections for dissolved solids are those presented by Larson and Buswell (12). In applying these corrections, Langelier's simplified method (1) for computing ionic strength was used: $\mu = 0.000025 \times$ ppm total dissolved solids.

The corrections for ionic strength are:

$$\log \frac{1}{[H^+]} = pH - \frac{0.5\sqrt{\mu}}{1 + 1.5\sqrt{\mu}} \quad [13]$$

$$pK_w' = pK_w - \frac{\sqrt{\mu}}{1 + 1.4\sqrt{\mu}} \quad [14]$$

$$pK_1' = pK_1 - \frac{\sqrt{\mu}}{1 + 1.4\sqrt{\mu}} \quad [15]$$

$$pK_2' = pK_2 - \frac{2\sqrt{\mu}}{1 + 1.4\sqrt{\mu}} \quad [16]$$

The equations used for the alkalinity nomographs were derived from those presented by Langelier and DeMartini. In the pH range of 6.0 to 12.0, the value of $[H^+]$ is insignificant; therefore it has been dropped from the denominator of the right hand term of the equations for bicarbonate and carbonate alkalinities. Also, in these equations, ppm $[OH^-]$ has been substituted for the term $50{,}000 \dfrac{K_w'}{[H^+]}$. The equations then become:

$$\text{ppm hydroxide alkalinity} = [OH^-] = 50{,}000 \frac{K_w'}{[H^+]} \quad [17]$$

$$\text{ppm carbonate alkalinity} = 2[CO_3^{--}] = \frac{[\text{Alky}] - [OH^-]}{1 + \dfrac{[H^+]}{2K_2'}} \quad [18]$$

$$\text{ppm bicarbonate alkalinity} = [HCO_3^-] = \frac{\text{Alky} - [OH^-]}{1 + \dfrac{2K_2'}{[H^+]}} \quad [19]$$

It should be noted that the carbonate alkalinity, as ppm $CaCO_3$, is twice the carbonate-ion concentration and this should be clearly stated in these equations to avoid error when an attempt is made to apply the carbonate-ion concentration to other problems.

The following equation, derived from that given by Larson and Bus-

well (12), was used for the free carbon dioxide nomograph (Fig. 4):

$$\text{ppm free } CO_2 = \frac{0.88 \times [H^+] \times [HCO_3^-]}{K_1'} \quad [20]$$

For natural waters with pH values below 7.5, the total alkalinity may be

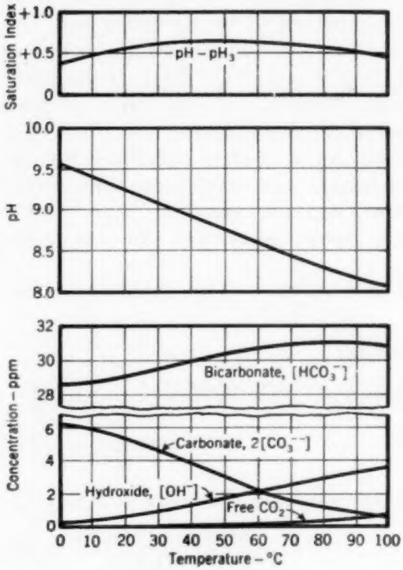


Fig. 5. Effect of Temperature on pH, Saturation Index, Free Carbon Dioxide, and the Three Forms of Alkalinity

Water had total alkalinity of 35 ppm; pH at 15 C was 9.3; calcium content was 20 ppm; and total solids, 200 ppm.

substituted for $[HCO_3^-]$ without significant error.

General Discussion

1. In preparing the tables and nomographs presented here, the values used for the ionization constants were those of Harned and associates (13–15), extrapolated to 100 C.

2. The nomographs are just as valid for a predicted pH value as for one that has been determined by the pH meter and make it possible to evaluate the free carbon dioxide content and the three forms of alkalinity at these other temperatures.

3. Figure 5 shows how the pH value, saturation index, free carbon

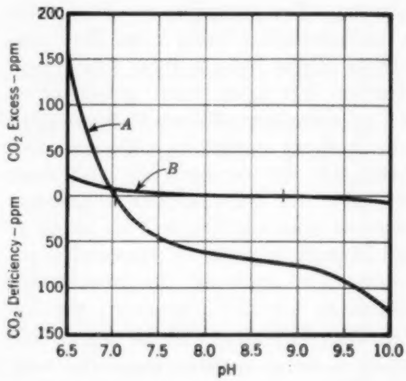


Fig. 6. Comparison of Carbon Dioxide Excess and Deficiency in Waters of Low and High pH_s Values

Carbon dioxide determination made at 15 C. Curve A: *alkalinity, 310 ppm; calcium, 100 ppm;* pH_s, *7.03; total carbon dioxide at pH 7.03 = 340 ppm. Curve* B: *alkalinity, 32 ppm; calcium, 20 ppm;* pH_s, *8.84; and total carbon dioxide at pH 8.84 = 27.4 ppm.*

dioxide, and the three forms of alkalinity of a typical lime-softened water vary, theoretically, with the temperature. In actual practice it would be necessary to calculate these values for only a few critical temperatures. Various other charts can be similarly prepared to show some particular effect of temperature upon carbonate equilibria.

4. In addition to their use in predicting the effect of temperature on

pH, the tables can be used to obtain a quantitative measure of the stability of a water toward calcium carbonate. This property can be measured not only by the excess or deficiency of calcium carbonate, but also by the deficiency or excess of carbon dioxide. If the total carbon dioxide is determined at the actual pH and also at the pH_s value, the excess or deficiency of carbon dioxide is determined by: $C - C_s = CO_2$ excess or deficiency. A minus answer—that is, a deficiency—indicates scale-forming qualities. Thus, a property, the directional tendency of which is usually measured by the saturation index, can be expressed by a quantitative value.

Figure 6 is a plot of the excess and deficiency carbon dioxide for two waters, one with a high and one with a low pH_s value, over a pH range of 6.5 to 10.0. It can be seen that if the water with the high pH_s has a saturation index of + 0.5, the carbon dioxide deficiency is only about 2 ppm, and little scale would be deposited. If the water with the low pH_s value has a saturation index of + 0.5, however, the deficiency is about 47 ppm, and the scale-depositing tendency would be greatly increased.

5. Some accuracy has been sacrificed in the nomographs in order to include a wide pH range. Two or three charts for each form of alkalinity, each with a narrower pH range, would, of course, give greater accuracy.

6. A nomograph was prepared for the evaluation of the pH_s, but has not been included here, as it checks very closely with the one presented by Hoover (16) some time ago.

7. Alkalinities should be determined as accurately as possible, using an indicator that has its end point at the true equivalence point for the amount of alkalinity being determined. For the pH determination, the glass electrode should be used and it should be standardized against a buffer solution of approximately the same pH as the sample.

Summary

A method for predicting the pH value a water would have, under the stated limiting conditions, at a temperature other than that at which the pH value is determined, has been presented. It is felt that the method is based upon valid assumptions, that it has certain advantages of flexibility and simplicity, and that its value in any studies of carbonate equilibria is obvious.

A series of nomographs is also presented, which makes possible the rapid evaluation of the free carbon dioxide and the three forms of alkalinity at any temperature at which the pH value is determined, as well as at any temperature at which the pH value is predicted by the above or any other method. Corrections for the effect of ionic strength have also been incorporated in these nomographs.

References

1. Langelier, W. F. The Analytical Control of Anti-corrosion Water Treatment. Jour. AWWA, **28**:1500 (1936).
2. DeMartini, F. E. Corrosion and the Langelier Calcium Carbonate Saturation Index. Jour. AWWA, **30**:38 (1938).
3. Moore, E. W. Graphic Determination of Carbon Dioxide and the Three Forms of Alkalinity. Jour. AWWA, **31**:51 (1939).
4. Amorosi, A. M. & McDermet, J. R. The Calculations of the Distribution of Carbon Dioxide Between Water and Steam. Proc. Am. Soc. Testing Materials, **39**:1204 (1939).

5. McKinney, D. S. The Calculation of Equilibria in Dilute Water Solutions. Proc. Am. Soc. Testing Materials, **39**:1191 (1939).
6. Powell, S. T.; Bacon, H. E.; & Lill, J. R. Corrosion Prevention by Controlled Calcium Carbonate Scale. Ind. Eng. Chem., **37**:842 (1945).
7. Powell, S. T.; Bacon, H. E.; & Knoedler, E. L. Corrosion Prevention by Controlled Calcium Carbonate Scale. Ind. Eng. Chem., **40**:453 (1948).
8. Langelier, W. F. Chemical Equilibria in Water Treatment. Jour. AWWA, **38**:169 (1946).
9. ———. Effect of Temperature on the pH of Natural Waters. Jour. AWWA, **38**:179 (1946).
10. Green, Jerome. Effect of Temperature on pH of Alkaline Waters. Ind. Eng. Chem., **41**:1795 (1949).
11. *Standard Methods for the Examination of Water and Sewage.* Am. Public Health Assn. & Am. Water Works Assn., New York (9th ed., 1946).
12. Larson, T. E. & Buswell, A. M. Calcium Carbonate Saturation Index and Alkalinity Interpretations. Jour. AWWA, **34**:1667 (1942).
13. Harned, H. S. & Owen, B. B. *The Physical Chemistry of Electrolytic Solutions.* Reinhold Publishing Co., New York (1950), pp. 485, 492.
14. Harned, H. S. & Scholes, S. R. The Ionization of HCO_3^- From 0° to 50°. Jour. Am. Chem. Soc., **63**:1706 (1941).
15. Harned, H. S. & Bonner, F. T. The First Ionization of Carbonic Acid in Aqueous Solutions of Sodium Chloride. Jour. Am. Chem. Soc., **67**:1206 (1945).
16. Hoover, C. P. Practical Application of the Langelier Method. Jour. AWWA, **30**:1802 (1938).

Materials Controls Being Liberalized

The National Production Authority is revising CMP Reg. 5—Maintenance, Repair and Operations (MRO) and CMP Reg. 6—Construction, to liberalize the requirements governing the water, sewage and industrial wastes industries. It is anticipated that these changes, being made in lieu of a new M order, will be announced during April 1952.

Percolation & Runoff

KC '52 roundup time is gallopin' around and if you ain't already laid out your gear and started gravitatin' thataway, you'd better start gallopin' too. Not just the rootin', tootin', and shootin' that'll be goin' on—especially on Whoopee Tuesday—but the powerful powwowing as well as hoss tradin' that always shine at AWWA's brand of blowout should make you sharpen your spurs right now! *Which is to say:*

The date of the Kansas City Conference is approaching rapidly, and if you have not yet made your plans and reservations for attendance, it will be necessary now to do so expeditiously. Not just the entertainment and good fellowship that will be part of the conference activities—especially at Tuesday night's informal event—but the impressive program of technical sessions and the opportunity to examine and purchase the latest and best in water works equipment that always feature AWWA's annual conferences should provide adequate incentive to make your participation in the affair appear desirable! *Which is also to say:*

KC '52—May 4–9—Technical Sessions—Exhibits—Social Events—Cowtown Atmosphere—STEAK—Yippee!

KC '52 does, by the way, give us the opportunity to resurrect a couple of old favorites long since dead of respectability. We mean, of course, those two short cuts to the basic source of water supply—seasweetening and cloudcoaxing. Both in the headlines recently, both will be on the program at KC.

Actually it was more work by Walter Juda, JOURNAL author of last January and technical director of Ionics, Inc., that put desalinization not only on the front pages, but in the editorials as well, of the nation's newspapers last February. News and views then both saluted the announce-

(Continued on page 2)

(Continued from page 1)

ment of a new ion-exchange-membrane method of separating the salt from the sweet and producing drinkability at a cost of 10 to 20 cents per 1,000 gal—still high, but several steps in the right direction from the 50-cent price of distillation.

It was a windfall rather than a rainfall that brought rainmaking back at about the same time—the discovery of a mechanical error in the summons and complaints of 120 damage suits totaling approximately $2,000,000 which had been brought against New York City for its cloud seeding operations of 1950. Thrown out of court, the cases could not be reinstituted because of a statute of limitations. Windfall, too, may be the patent issued about then to General Electric Co. on the dry-ice method of artificial nucleation discovered by Vincent J. Schaefer on November 13, 1946.

Out at KC two practiced hands will be manipulating these techniques —Prof. E. D. Howe of the Univ. of California, an old salt at seasipping; and ex-Prof. Irving P. Krick, formerly of the California Inst. of Technology, now head of Water Resources Development Corp., a big splash at cloudcoddling. The sea on tap, the sky on top—what price water?

Noitadiroulf may be the word these days. Noitadiroulf, of course, is fluoridation in reverse—and in reverse is where fluoridation seems suddenly to be, if not from coast to coast, at least from Seattle, Wash., to Northampton, Mass. Not as significant as all that, perhaps, the news of two simultaneous setbacks to public health's premier pinup is still sort of startling.

First reverse came on March 11, when 86,230 of Seattle's voters overwhelmed 44,814 exfriends of theirs in turning down a proposal to fluoridate. Inasmuch as the controversy leading up to the vote is said to have overshadowed even the concurrent hot mayoralty race, it seems certain that the voters had ample opportunity to look before leaping.

In the second reverse, two days later at Northampton, 1,375 residents, who did their looking after the leap, petitioned for repeal of the action authorized by their city council ten months before. And when Superior Judge Daniel O'Brien issued a temporary order restraining the water utility from continuing addition of fluorides, the water commissioner interpreted the order as banning addition of all chemicals. Warning residents to boil their water, he discontinued chlorination as well and, thereby, drew a quick rebuke for overobedience.

Tempted as we are to speculate about the present status of water treatment practice if the same measure of emotion and politics had flavored the discussion of other techniques long since routine, we, with Newbold Morris, had better keep our shirt on, and better, too. Noitadiroulf to you!

(Continued on page 4)

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Soft drinking as well as soft driving is afforded by the Pennsylvania Turnpike, the new superhighway that provides 327 miles of divided-lane travel with no traffic lights, stop signs, or cross traffic. Water for the combination service station-restaurants located at intervals of from 30 to 45 miles along the way is obtained from private wells, which usually provide supplies that are adequate and pure, but too hard for use in automobile radiators or in restaurant kitchens. First aid was rendered by Hungerford & Terry, Inc., with specially designed, fully automatic, twin softening units that pass the supply through Rohm & Haas "Amberlite IR-120" ion-exchange resin. Better water, better roads.

Hard drinking as well as hard driving seemed to be the trouble in Orange, N.J., one subfreezing night last February when water department crewmen spent the night rendering first aid to a hydrant felled by a misguided vehicle. Actually, though, that turned out to be hard water too (ice), inexpertly approached by a 17-year-old driver working on his learner's permit. And speaking of hard knocks—between drivers and dogs, it's really a hydrant's life that's worthy of the cliché.

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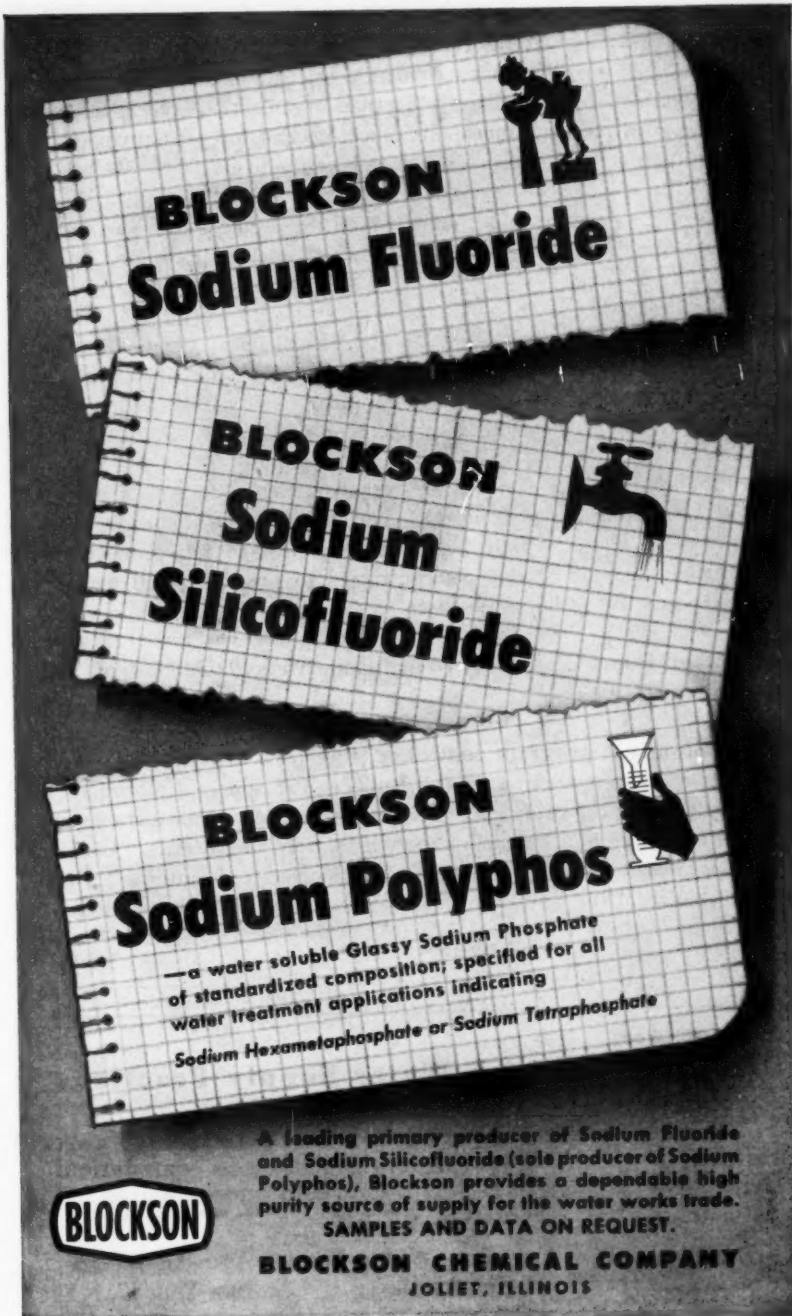
BLOCKSON
Sodium Fluoride
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Sodium
Silicofluoride
BLOCKSON
Sodium Polyphos
—a water soluble Glassy Sodium Phosphate of standardized composition; specified for all water treatment applications indicating
Sodium Hexametaphosphate or Sodium Tetraphosphate
A leading primary producer of Sodium Fluoride and Sodium Silicofluoride (sole producer of Sodium Polyphos), Blockson provides a dependable high purity source of supply for the water works trade.
SAMPLES AND DATA ON REQUEST.
BLOCKSON
BLOCKSON CHEMICAL COMPANY
JOLIET, ILLINOIS

(*Continued from page 4*)

Herbert C. Lindsten, Winnipeg district manager for Wallace & Tiernan Ltd., died on February 27 after a brief illness. He was 51 years old. A member of the Wallace & Tiernan organization since 1925, when he was assigned to the Minneapolis office, he had for years managed the Winnipeg district for the Canadian branch of the firm.

Albert J. Vernier, superintendent of the water department of Ira Township, Michigan, died suddenly of a heart attack on February 24. He was 55 years old.

Charles W. Wright, president and chairman of the board of the Badger Meter Mfg. Co., died suddenly on Feb. 14, at the age of 60.

He had been with the Badger organization since 1924, and had been its head since 1929. Previously he had been with A. O. Smith Corp. for 10 years.

In addition to manufacturing water meters, the firm produces munitions equipment for the government. During the last war, even the basement workshop of the Wright home was converted to war production, as Mrs. Wright and her friends subcontracted to produce small drilled or machined parts for aerial bomb fuses.

Chicago Pump Co. has moved its headquarters to 622 Diversey Parkway, Chicago 14, Ill.

An automatic program controller to be used in conjunction with a cam-operated pressure valve on the Builders-Providence Chlorinizer has been developed by the company. The program feed method permits chlorine feed according to a regularly recurring pattern or patterns. Cams are interchangeable to meet varying needs for chlorine-feed patterns. Details are available from the company, 345 Harris Ave., Providence 1, R.I.

(*Continued on page 8*)

(Continued from page 6)

Hopalong Cassidy ain't so much! Same old William Boyd from our TV chair that we used to see from the peanut gallery of the local cinema. Nothing added but idolatry and testimonials. But Francis X. Bushman, now—he always was an idol of a different matinee. And now, as never before, he's ours. At any rate, he is if he really is the groundwater hydrologist of that name who just joined AWWA from the staff of the State Bureau of Mines & Mineral Resources at Socorro, N.M. Until we're sure, we'll hold our breath as our mothers used to do.

Norman E. Tucker has been promoted to vice-president in charge of sales of Refinite Corp. He retains his post as manager of the Government Contracts Div., and in addition will supervise the operations of the Sales Div. He has been associated with the Omaha firm since 1949, before which he was general sales manager of the Elgin Softener Corp.

Richard J. Ritchie, formerly vice-president of Pepsi-Cola Co. in charge of chemical laboratories and syrup and concentrate production, has joined Riches-Nelson, Inc., of New York.

(Continued on page 10)

(*Continued from page 8*)

"Just add water" and no one will complain. "Just add hydrogen oxide" and you may be investigated. But who can blame the man on the street for feeling just a wee bit queasy about feeding his friends polymers of amino acids or of hexoses, or glyceride esters of palmitic, oleic, and stearic acids? We, too, can admit to feeling somewhat more comfortable in discussing meat, sugar, and fats. And although we are just as certain as any of the experts that most of the current hue and cry about the poisoning of food by chemical additives is either uninformed or purposeful, we have a feeling that at least some of the blame must fall upon the food and chemical companies themselves for feeding innocent advertising copywriters an overdose of vocabulary.

In the deliberations of the Delaney Committee in the House of Representatives these days, we get, in addition to a fund of valuable information concerning the role of chemicals in food production, processing, and packaging, a tremendous amount of frightened misunderstanding either by laymen or by experts from the wrong scientific rut. Water is a food too, and such chemical additives as chlorine, alum, and fluoride are lethal enough to frighten anyone who cannot understand arithmetic. What we want is not less information, though, but information that can be understood by less of a chemist. What we want, too, is people who will not start yelling bloody murder because the railroad train on which they ride once killed a man. What we want, really, is egg in our beer. "Just add water" there and we'll do the yelling.

To simplify the location of advertisements in the JOURNAL, the alphabetical "List of Advertisers" will, beginning with this issue, appear on the last page but two (in this issue, p. 118 *P&R*). In back-to-front order, the editorial material immediately preceding it will be the "Index of Advertisers' Products" (in this issue, pp. 116, 114 and 112 *P&R*), and "Coming Meetings" (pp. 110 and 108 *P&R*).

(*Continued on page 12*)

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"Rivera stay 'way from my floor" has been the thought of every water works man who has seen, in *Life* or in the Chicago *Tribune,* the Mexican artist's heebie-jeebification of the aqueduct floor at the new Mexico City water works. There, algae and protozoa, two or more feet across their sinister and unappetizing shapes, practically crawl with the brightness of Rivera's brush. And if the superintendent feels crawly too, at least he can be thankful that it is the influent rather than the effluent through which these creatures will be seen. Art is fine for art's sake; murals, or even floorals, may be fine for water utility buildings and equipment; but ten thousand times *Daphnia* or *Cyclops* will never help public relations.

James W. Crawley has been appointed Hays Manufacturing Co. representative in Kansas, Missouri, Oklahoma and Arkansas. Another recent assignment is of Henry L. Wheeler, in the New York and New Jersey territory. Wheeler succeeds Robert Hutchings, who has been promoted to the post of assistant sales manager in charge of the Industrial Sales Div. of the company.

(Continued on page 14)

(*Continued from page 12*)

Cosmic in osmic literature must be a new fifteen-buck book, called *Odors and the Sense of Smell,* which was brought to our attention recently by its publishers, Airkem Inc. of New York City, providers of an "odor counteractant service for industrial and professional use." Whether Airkem engineers can help you deodorize your water or not, we haven't yet investigated, but we're willing to take their word for the fact that *OATSOS* is "the first authoritative bibliography of osmic literature" and that it contains "over four thousand references," listing "virtually everything written on osmics from about 200 BC through 1947 AD." Why 200 BC we're not certain either, but presumably that signalized the end of the "Wizard" and the beginning of "osmology." Never having seen the book, we must admit that the idea of Pulitzer Prize suggested itself; but sight unseen we have no hesitation in naming it "the enstinklopedia of almost all time."

Holding our nose for the moment, we can open our ears and catalog a collection of sounds which includes a singing river, barking sands, and hissing stars. Inasmuch as the river is the Pascagoula of Mississippi, the sands those of Mana beach in Hawaii, and the stars those of outer space, we have more or less discounted the apparent inter-relationship. Fish, escape of natural gas, or sand on a slate river bed are said to be the probable causes of the Mississippi songstream; hollow sand grains that "snap, crackle, and pop" like Kellogg's Rice Krispies set up the Hawaiian howls; and radio waves emitted by our stellar companions have been found to register the continual disapproval of our own radiotic emanations. Where does water come in? You're interested in filtration aren't you, and radioactive contamination?

John N. Welsh, associate director of Hall Laboratories, Inc., is to handle all service contracts and other business activities on boiler feedwater, process and waste water problems.

(*Continued on page 84*)

Correspondence

Measure for Measure

To the Editor:

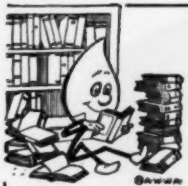
May I call your attention to what appears to be an error on page 61 of the January 1952 JOURNAL in the listing of "New JOURNAL Abbreviations." Note that the abbreviation for "cubic centimeter" is given incorrectly as "ml." On page 62, of course, "ml" is correct as the abbreviation for "milliliter."

If this is but one of many letters on this matter, you may deposit it in the wastepaper basket without further ado.

D. M. HANNA

Supt. of Distr., Water Div.
Utilities Commission
Windsor, Ont.
Feb. 19, 1952

As a matter of fact Hawkeye Hanna was alone in not taking our measure, but because the error isn't what it seems, we ought to explain. "For 'cubic centimeter,'" we had meant to say, "use 'ml.'" True, 1 cubic centimeter actually equals only 0.999973 ml, but understanding that they were originally meant to be equal and figuring that the 0.000027 to 0.000028 ml by which the one exceeds the other is even less than a drop in the bucket, we've been anxious to let bygones be. Anyway, now that most people start with milliliters, we have much less on our conscience than we had in times past.—ED.



The Reading Meter

Nomography and Empirical Equations. *Lee H. Johnson. John Wiley & Sons, Inc., New York (1952) 150 pp.; $3.75*

The serious student of the application of mathematical tools to the solution of many technical problems may find this volume a useful aid. Techniques for the construction of nomographs, including methods of analysis to determine the optimum arrangement of scales for convenience and accuracy, are related to the basic types of equations they express. The final chapters are devoted to curve fitting—the procedure for establishing and determining empirical equations for given data, and the curves that fit them.

Graphic means of solving problems of a recurring nature are simpler and quicker to use than algebraic means, and the person with a flair for mathematics may profitably devote some time to reducing such problems to nomographic form.

Water: Giver of Life; *Master and Servant of Mankind. Electric Water Systems Council, National Assn. of Domestic and Farm Pump Manufacturers, 39 S. LaSalle St., Chicago 3, Ill. (1952) 24 pp.; paperbound; 10¢*

This unusual booklet, printed in full-color, comic-book style, was developed to sell pressure water systems to homes, farms and institutions in rural areas. Background information on the importance of water is graphically presented, and the cartoon history of the quest for pure water is in at least one respect more ambitious than M. N. Baker's 527-p. monograph on the same subject, as it goes back to prehistory for its starting point. Methods of water collection and distribution used in ancient Egypt, Greece, and Rome, in Biblical, medieval and (in this country) colonial times are all shown as a prelude to present-day methods used by large and small systems. Some principles of geology, hydrology and pump action are presented simply and understandably, as well as, of course, the publisher's selling message.

(*Continued on page 20*)

The Reading Meter

(Continued from page 18)

Industrial Water Pollution: *Survey of Legislation and Regulations. Marvin D. Weiss. Chemonomics, Inc., 400 Madison Ave., New York 17, N.Y. (1951) 142 pp.; paperbound; $5.00*

Industrial Water Pollution consists of a state-by-state summary of antipollution legislation, compiled by members of R. S. Aries & Assoc., a New York consulting firm, for clients in the chemical process industries. Penalties, quality standards, and special requirements are detailed in the digest of regulations for each state. Information on interstate and federal pollution control is included, and appendixes give the composition and addresses of state water pollution control commissions. Water quality criteria adopted by several interstate agencies are also furnished.

(Continued on page 22)

The Reading Meter

(Continued from page 20)

Public Service Guide to Fire Protection. *Reader's Digest Assn., Inc., Pleasantville, N.Y. (1952) 40 pp.; paperbound; 25¢*

This compilation of material, assembled with the aid of the National Fire Protection Assn., has as its aim the promotion of fire-consciousness and fire safety. Although most of the articles reprinted from the *Reader's Digest* and other sources will have little concrete value for the person interested in specific ways and means for lowering fire losses, a few offer how-to-do-it advice for extinguishing small or rural fires, increasing fire department efficiency, checking the fire safety of premises, and other useful matters. The pill is heavily sugared with the story-telling style of popular magazine exposition, and even the little anecdotes used to fill out the bottom of last pages of newstand issues of *Reader's Digest* have been included.

Membership Changes

NEW MEMBERS

Applications received February 1 to February 29, 1952

Ameen, Joseph Saied, San. Engr., State Board of Health, Raleigh, N.C. (Jan. '52) *P*

Anderson, Byron L., Sales Repr., Hays Mfg. Co., 112 W. Stadium Ave., West Lafayette, Ind. (Jan. '52)

Ansari, M. Y., Graduate Student, Mech. Eng., Univ. of Toronto, 40 College St., Toronto, Ont. (Jan. '52)

Aube, Harry J., Chief Engr. & Supt., Pumping Station, Sault Ste. Marie, Mich. (Jan. '52) *P*

Baarslag, Hendrik S., Jr., Sr. Engr., City Water Dept., Room 402, City Hall, Tacoma, Wash. (Jan. '52) *M*

Baker, Arthur, Chief Engr., Water Works, La Porte, Ind. (Jan. '52)

Barbier, Charles M., Asst. Engr. & Surveyor, Water Dept., City Hall, Newark, N.J. (Jan. '52) *M*

Beaulieu, Louis Philippe, Mgr., Engine, Pump & Elec. Div., The Canadian Fairbanks-Morse Co. Ltd., 980 St. Antoine St., Montreal, Que. (Jan. '52)

Bedford Park Water Dept., H. C. Swanson, Supt., Public Works, 6535 S. Central Ave., Chicago 38, Ill. (Corp. M. Jan. '52) *M*

Bell, Richard, Supt., Board of Public Affairs, Leipsic, Ohio (Jan. '52) *M*

Berger, Bernard B., Sr. San. Engr., U.S. Public Health Service, Washington, D.C. (Jan. '52) *PR*

Berry, Rollie DeWayne, Water Purif. Plant Supt., Lewiston Orchards Irrigation Dist., 1520 Powers Ave., Lewiston, Idaho (Jan. '52) *MP*

Black, John Bunyan, San. Engr., Office of the Post Engr., Fort Belvoir, Va. (Jan. '52) *MPR*

Bogan, Richard H., Graduate Student, Dept. of Civ. & San. Eng., Massachusetts Inst. of Technology, 269 Westgate St., W., Cambridge 39, Mass. (Jr. M. Jan. '52)

Bostwick, William Moreau, Pres., Bostwick, Inc., 211 Broadway, Daytona Beach, Fla. (Jan. '52)

Bradway, Otis B., Owner, Mt. Summit Water Co., Bradway Bldg., 1215 Race St., New Castle, Ind. (Jan. '52) *M*

Brunton, J., Service Engr., Sherman Machine & Iron Works, 901 N.E. 31st St., Oklahoma City, Okla. (Jan. '52) *MP*

Buercklin, Marion A., Jr., San. Chemist, City Water Dept., Oklahoma City, Okla. (Jan. '52) *P*

Burbo, Walter James, Water Plant Operator, Pennsylvania Salt Mfg. Co., Wyandotte, Mich. (Jan. '52) *P*

Bushman, Francis X., Groundwater Hydrologist, State Bureau of Mines & Mineral Resources, Socorro, N.M. (Jan. '52) *R*

Butler, Michael, Gen. Mgr., Tank Repair & Maint. Service, Box 36, Bowling Green, Ohio (Jan. '52) *M*

Clark, William Stewart, Chief Engr., Earl W. Baker & Co., Box 102-W., Oklahoma City, Okla. (Jan. '52) *PR*

Cobb, Fred, Cobb Eng. Co., 519½ W. Main St., Oklahoma City, Okla. (Jan. '52) *PR*

Collinsville, City of, Albert R. Delbartes, Comr. of Water Works & Sewerage, 125 S. Center St., Collinsville, Ill. (Mun. Sv. Sub. Jan. '52) *MPR*

Connorsville Munic. Water Works, James West, Supt., Connorsville, Ind. (Corp. M. Jan. '52)

Cooil, T. R., Sr. Engr., H. W. Lea, 1226 University St., Montreal, Que. (Jan. '52)

Copland, Robert P., Asst. Gen. Mgr., The Canada Valve & Hydrant Co., Ltd., Brantford, Ont. (Jan. '52)

(*Continued on page 32*)

(*Continued from page 30*)

Corbett, Don Melvin, Dist. Engr., U.S. Geological Survey, Surface Water Branch, 311 W. Washington St., Indianapolis, Ind. (Jan. '52) *R*

Crawford, George B., Jr. Engr., Gore & Storrie, Cons. Engrs., 1130 Bay St., Toronto, Ont. (Jan. '52)

Daly, Walter J., *see* Pioneer Salt Co.

Davis, Gordon E., Hydr. Engr., U.S. Geological Survey, 311 W. Washington St., Indianapolis, Ind. (Jan. '52) *R*

Day, Kenneth A., Safety Officer, Dept. of Water, 735 Randolph St., Detroit 26, Mich. (Jan. '52) *M*

De Camp, Charles M., Water Comr., Neligh, Neb. (Jan. '52) *MPR*

Dehner, Paul J., Supt. of Utilities, City Hall, Woodbury, N.J. (Jan. '52)

Delbartes, Albert R., *see* Collinsville (Ill.)

East Chicago Dept. of Water Works, John B. Moldovan, Supt., 4733 Olcott Ave., East Chicago, Ind. (Corp. M. Jan. '52) *MP*

Edwards, Rodney Albert, Safety Director, American Water Works Service Co., 121 S. Broad St., Philadelphia 7, Pa. (Jan. '52) *M*

Elliott, Edward H., *see* Fischer & Porter Co.

Elwood Munic. Water Works, Harry B. Overesch, Supt. of Utilities, Elwood, Ind. (Corp. M. Jan. '52)

Epplett, Harold Harry, Meter Shop Foreman, Portland Water Bureau, 1900 N. Interstate Ave., Portland, Ore. (Jan. '52) *M*

Ern, Rochford H., *see* Ern Construction Co., Inc.

Ern Construction Co., Inc., Rochford H. Ern, Route 29, Springfield, N.J. (Assoc. M. Jan. '52)

Faivre, Victor W., Supt., Wilmington Suburban Water Corp., Claymont, Del. (Jan. '52) *M*

Fischer & Porter Co., Edward H. Elliott, Field Engr., Hatboro, Pa. (Assoc. M. Jan. '52)

Fowler, H. B., Chief Ranger, Fish & Game Dept., City Water Dept., Municipal Bldg., Oklahoma City 2, Okla. (Jan. '52) *R*

Giannini, A. G., *see* Hammond (Ind.) Dept. of Water Works

Glysson, Eugene A., Instructor, Civ. Eng. Dept., Univ. of Michigan, Ann Arbor, Mich. (Jan. '52) *P*

Griggs, Donald M., Maint. Engr., State Soldiers Home, Lafayette, Ind. (Jan. '52) *MP*

Guild, George S., Water Supt., Water Dist., Frewsburg, N.Y. (Jan. '52) *MP*

Gulick, Howard E., Prin. Engr. & Asst. Gen. Mgr., Public Service Dept., 119 N. Glendale Ave., Glendale 6, Calif. (Jan. '52) *M*

Hammond Dept. of Water Works, A. G. Giannini, Supt. of Operations, City Hall, Hammond, Ind. (Corp. M. Jan. '52) *MP*

Harvey, Edgar W., *see* Hyde Park (N.Y.) Fire Dept., Inc.

Haverstick & Co., Inc., J. S. Zahniser, Pres., 45-55 Ford St., Rochester 1, N.Y. (Assoc. M. Jan. '52)

Hawkins, Howard J., *see* Hawkins Chemical Co.

Hawkins Chemical Co., Howard J. Hawkins, Owner, 3100 E. Hennepin Ave., Minneapolis 13, Minn. (Assoc. M. Jan. '52)

Heffelfinger, Paul Raymond, Civ. Engr., Water Div., 402 City Hall, Tacoma, Wash. (Jan. '52)

Highton, James L., City Engr. & Supt. of Utilities, City Hall, Renton, Wash. (Jan. '52) *MPR*

Hinkle, Edward, Water Supt., City Hall, Garnett, Kan. (Jan. '52) *M*

Hoard, Kenneth Spencer, Field Engr., Bristol Co., Box 3180, Charlotte, N.C. (Jan. '52) *M*

Holland, Max, Asst. City Mgr., & Supt. of Utilities, Dept. of Utilities, Camden, S.C. (Jan. '52)

Hughes, Edmund Favre, Asst. to Gen. Supt., Sewerage & Water Board, 526 Carondelet St., New Orleans 12, La. (Jan. '52) *M*

Hunley, William, Supt., Water Plant, Water & Light Dept., Falls City, Neb. (Jan. '52)

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(*Continued from page 32*)

Hyde Park Fire Dept., Inc., Edgar W. Harvey, Water Works Supt., Crum Elbow Pumping Station, Hyde Park, N.Y. (Corp. M. Jan. '42) *MP*

Jaeger Machine Co., The, W. L. Wolfe, Exec. Asst., 550 W. Spring St., Columbus, Ohio (Assoc. M. Jan. '52)

Janssen, Arthur, Purchasing Agent, San Diego Bay Div., California Water & Telephone Co., 19 W. 9th St., National City, Calif. (Jan. '52) *M*

Jones, Vearl W., Supt., Light & Water, Enterprise, Kan. (Jan. '52) *MP*

Jordan, Perry L., Supt., Munic. Water & Light Plant, 522 N. 4th Ave., Washington, Iowa (Jan. '52)

Joseph, Arnold B., San. Engr., Eng. Section, Headquarters Second Army, Fort Meade, Md. (Jan . '52) *MPR*

Jungkurth, Walt H., Borough Water & Utility Engr., Stone Harbor, N.J. (Jan. '52) *MPR*

Kenan, Robert C., Sales Engr., Tar Products Div., Koppers Co., Inc., 122 S. Michigan Ave., Chicago, Ill. (Jan. '52) *MR*

King, John T., Sales Engr., Rockwell Mfg. Co., 611 S. English St., Springfield, Ill. (Jan. '52)

Kirkby, C. E., Gen. Mgr., Woodstock Public Utilities, 524 Dundas St., Woodstock, Ont. (Jan. '52)

Kruegel, J. L., Supt., Distr. System, 137 S. Kirkwood Rd., Kirkwood 22, Mo. (Jan. '52) *MPR*

Lewis, Raymond L., Application Engr., Economy Equipment Co., 609 Minnesota Ave., Kansas City, Kan. (Jan. '52) *MP*

Linebarier, Myron J., Supt., Munic. Water Works, Camden, Ark. (Jan. '52) *M*

Lingren, Merton W., Supt., Water Works, LaPorte, Ind. (Jan. '52)

Lucas, Harley E., *see* Stockton (Kan.)

Mathews, Frank E., Supt., Water Works, 420 N. Pearl St., Ellensburg, Wash. (Jan. '52) *MP*

McQuillan, Robert George, Engr., Township of North York Health Dept., 5248 Yonge St., Willowdale, Ont. (Jr. M. Jan. '52)

Mitchell, Marvin G., Dist. Sales Mgr., Chicago Bridge & Iron Co., 507 Healey Bldg., Atlanta, Ga. (Jan. '52)

Moldovan, John B., *see* East Chicago (Ind.) Dept. of Water Works

Moore, George R., Mayor & Supervisor, Water Dept., Gould, Ark. (Jan. '52) *M*

Morrison, John H., *see* Morrison-Maierle, Inc.

Morrison-Maierle, Inc., John H. Morrison, Pres., Civic Center Bldg., Helena, Mont. (Corp. M. Jan. '52) *P*

Murphrey, James Walter, Chemist & Bacteriologist, Light, Gas & Water Div., 2681 Lombardy St., Memphis, Tenn. (Jan. '52) *P*

Murray, Chester Edward, Acting City Engr., City Hall, Wenatchee, Wash. (Jan. '52) *P*

Murray, Hubert, City Engr., City Hall, St. Jerome, Que. (Jan. '52)

Myers, Harold D., Owner, Myers Meter Repair, 322 S. Martin St., Muncie, Ind. (Jan. '52)

Nasser, Camilo Pedro, Director, Power & Light Dept., Belem, Para, Brazil (Jan. '52) *MPR*

Nedervold, Glenn E., Engr., Water Div., Dept. of Public Utilities, 402 City Hall, Tacoma, Wash. (Jan. '52)

North, Ernest C., Chief of Valuation, Estimating & Specification Dept., Whitman, Requardt & Assocs., 1304 St. Paul St., Baltimore 28, Md. (Jan. '52) *M*

Overesch, Harry B., *see* Elwood (Ind.) Munic. Water Works

Petrey, Arthur W., Chief Chemist, Aluminum Co. of America, Box 120, Vancouver, Wash. (Jan. '52) *P*

Pioneer Salt Co., Walter J. Daly, Mgr., San. Div., 940 N. Delaware Ave., Philadelphia 23, Pa. (Assoc. M. Jan. '52)

Pittman, John C., Supt., Light & Water Plant, Houma, La. (Jan. '52) *P*

Ponce, Telmo, Student, Univ. of Minnesota, 516—15th Ave., S.E., Minneapolis 14, Minn. (Jr. M. Jan. '52)

Possenti, S. J., Supt., Water Treatment Plant, Box 613, Havre, Mont. (Jan. '52) *P*

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Purzycki, Edward J., Supt., Water Dept., 101 S. Main St., Manville, N.J. (Jan. '52) *MP*

Rason, C. Lorimer, Vice-Pres., The Canada Valve & Hydrant Co., Ltd., Brantford, Ont. (Jan. '52)

Richards, Harold B., Chairman, Board of Comrs., The Old Hickory Utility Dist. of Davidson County, 1100 Hadley Ave., Old Hickory, Tenn. (Jan. '52)

Roberts, Brian H., Mgr., Pump & Railroad Dept., Fairbanks, Morse & Co., Omaha, Neb. (Jan. '52)

Roberts, Claude M., Dist. Geologist, U.S. Geological Survey, Water Resources Div., Ground Water Branch, 311 W. Washington St., Indianapolis, Ind. (Jan. '52) *R*

Roller, Paul S., Director of Research, General Hydro Co., 1621 Connecticut Ave., Washington 9, D.C. (Jan. '52) *PR*

Rudder, Albert P., Dist. Mgr., Wallace & Tiernan Co., Inc., 111—17th St., N.W., Washington, D.C. (Jan. '52)

Russell, Jerome A. G., Div. Engr., California Water & Telephone Co., 2116 Huntington Dr., San Marino, Calif. (Jan. '52) *P*

Salisbury, Sheldon Allen, Supt., Miraflores Filtration Plant, Drawer "J", Pedro Miguel, Canal Zone (Jan. '52) *M*

Sanks, Floyd, Water Supt., Water Dept., Sidney, Neb. (Jan. '52) *MPR*

Santana, Manuel Francisco, Student, Univ. of Minnesota, 930—15th Ave., S.E., Minneapolis 14, Minn. (Jr. M. Jan. '52)

Seabolt, M. L., Plumber, Box 93, Mulberry, Ark. (Jan. '52)

Sellers, Jake L., Lake Abilene Filtration Plant Operator, City Water Dept., Abilene, Tex. (Jan. '52) *P*

Shamberger, Hugh Allan, State Engr., Carson City, Nev. (Jan. '52) *R*

Shugert, Mary A. (Miss), Supt., City Water Works, Loogootee, Ind. (Jan. '52) *MPR*

Simmons, R. A. G., Eng. Asst., Gore & Storrie, Cons. Engrs., 1130 Bay St., Toronto, Ont. (Jan. '52)

Skrinde, Rolf T., Student, Massachusetts Inst. of Technology, Graduate House, Box 619 C, Cambridge 39, Mass. (Jr. M. Jan. '52) *P*

Slater, Meredith, Supt., Munic. Water Works, South Whitley, Ind. (Jan. '52) *MR*

Smith, Henry D., Chairman, Water Dept., 142 Crescent St., Woodbury, N.J. (Jan. '52)

Solkoff, Ephraim, San. Engr., William C. Olsen & Assocs., 5 Exchange Pl., Raleigh, N.C. (Jan. '52) *MPR*

Speer, Thomas A., Supt. of Production, City Water Dept., Beaumont, Tex. (Jan. '52) *MP*

Stenner, John P., Dist. Mgr., The A. P. Smith Mfg. Co., 940 W. Princess Anne Rd., Norfolk, Va. (Jan. '52)

Stiles, Robert W., Engr., City of Alamo Heights, 6116 Broadway, San Antonio 9, Tex. (Jan. '52) *MR*

Stockton, City of, Harley E. Lucas, City Mgr., Stockton, Kan. (Corp. M. Jan. '52) *M*

Sullivan, Fred O., Sales Engr., Infilco Inc., 3755 N. 41st St., Milwaukee 16, Wis. (Jan. '52)

Sunn, Franklin Young Kong, Student, Massachusetts Inst. of Technology, 47 Westgate St., Cambridge 39, Mass.

Swanson, H. C., *see* Bedford Park (Ill.) Water Dept.

Taranoff, Peter P., Chief Chemist, St. Helens Pulp & Paper Co., St. Helens, Ore. (Jan. '52) *MP*

Tooker, William T., Jr., Mgr.-Jr. Partner, A. G. Bancker & Co., 67 Orchard St., Manhasset, N.Y. (Jan. '52)

Turner, Cecil H., Sales Engr., Calgon, Inc., Route 1, Box 70, Ada, Mich. (Jan. '52) *P*

Turner, Richard Thomas, Sales Repr., Mathieson Chem. Corp., 442 Post St., San Francisco 2, Calif. (Jan. '52) *MP*

Turnock, Ted, Supt., Water Works, South Bend, Ind. (Jan. '52)

Veal, Robert Lynton, City Supt., Rockmart, Ga. (Jan. '52) *M*

Waggoner, Norman E., MCB No. 8, Navy 115, Fleet Post Office, New York, N.Y. (Jan. '52) *P*

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Walley, A., Supt., East Gary, Ind. (Jan. '52)

Ward, James Edward, Sales Engr., Builders Iron Foundry, 1143 Greenleaf Ave., Wilmette, Ill. (Jan. '52) *M*

Welch, John Walter, Jr., Mgr., Brinkley Water Co., Brinkley, Ark. (Jan. '52) *MP*

West, James, *see* Connorsville (Ind.) Munic. Water Works

Wilson, Harold E., Asst. Civ. Engr., Water Dept., 215 W. Broadway, Long Beach 2, Calif. (Jan. '52) *MR*

Wolfe, W. L., *see* Jaeger Machine Co.

Won, Thomas H., Munic. Engr., Public Works Dept., Municipal Bldg., Garson, Ont. (Jan. '52)

Zahniser, J. S., *see* Haverstick & Co., Inc.

REINSTATEMENT

Davoust, Norbert J., Sr. San. Engr., South Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago 49, Ill. (Apr. '49)

Griffith, Emmett, Route 3, Vilonia, Ark. (July '49)

Sharts, Paul E., 280 Oakridge Ave., Summit, N.J. (Jan. '47)

Sitler, W. S., Engr., U.S. Public Health Service, Washington 25, D.C. (Jan. '46) *R*

LOSSES

Deaths

Behring, Walter E., Supt., Water Filtration Plant, Post Engrs., Camp Pickett, Va. (July '44)

Shaw, Walter A., Cons. Engr., 922 Oakwood Ave., Wilmette, Ill. (July '06) *M*

Sullivan, J. R., Mgr., Public Utilities Com., 524 Dundas St., Woodstock, Ont. (Jan. '42)

Resignations

Irwin, William F., 1256 Delta Ave., Cincinnati 8, Ohio (Oct. '38)

Lucas, Harley E., Civ. Engr. & Acting City Mgr., Box 388, Norton, Kan. (July '49)

Maierle, Joseph A., Vice-Pres. & Secy.-Treas., Morrison-Maierle, Inc., Civic Center Bldg., Helena, Mont. (Apr. '47)

Morrison, John H., Pres. & Chief Engr., Morrison-Maierle, Inc., Civic Center Bldg., Helena, Mont. (Jan. '46)

Proudfit, W. M., Chemist, B & B Eng. & Supply Co., Box 2531, Houston, Tex. (Oct. '48)

Suters, Frank, Dist. Mgr., California Water Service Co., 132 Main St., Petaluma, Calif. (Oct. '37) *M*

Swartz, Charles R., 213 Warren Way, East Point, Ga. (Jan. '49)

CHANGES IN ADDRESS

Changes received between February 5, and March 5, 1952

Adkins, William Witty, Supt., Water Dept., City Hall, Burlington, N.C. (July '40) *P*

Anderson, Felix A., Johnson & Anderson, Engrs., 1307 Pontiac State Bank Bldg., Pontiac, Mich. (Apr. '50) *MP*

Anderson, Martin E., 511 E. 8th St., Leadville, Colo. (Jan. '43) *M*

Andrews, John, Prin. San. Engr., State Board of Health, 1912 Craig St., Raleigh, N.C. (Jan. '49) *MP*

Andrews, W. S., Dist. Mgr., Pittsburgh Equitable Meter Div., Rockwell Mfg. Co., 7701 Empire State Bldg., New York 1, N.Y. (Jan. '41) *MR*

Aston, Royden N., Product Development Dept., Mathieson Chem. Corp., 735 Dixie Terminal Bldg., Cincinnati 2, Ohio (Jan. '46) *P*

Bakelite Co., Div. of Union Carbide & Carbon Corp., Howard L. Nickerson, Box 515, Ottawa, Ill. (Corp. M. Apr. '48) *R*

Barbehenn, Ralph L., Tech. Director, Tech. Div., Abestos Cement Products Assn., 201 E. 5th St., Plainfield, N.J. (Apr. '45) *MPR*

Bastian, Joseph, *see* Evansville (Ind.) Water Works Dept.

Bell, William E., Inst. of Inter-American Affairs, c/o U.S. Embassy, San Jose, Costa Rica (Oct. '48) *P*

Beltzner, Roy E., Supt., Water & Street Depts., Sewage & Treatment Plant, San Jacinto, Calif. (Apr. '49) *MPR*

Benjes, Henry H., 2916 W. 73rd St., Kansas City 5, Mo. (Jan. '50)

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Bettenburg, Townsend & Stolte, Architects & Engrs., Edward F. Kishel, 1437 Marshall Ave., St. Paul 4, Minn. (Corp. M. Apr. '47) *P*

Blackshaw, George E., Mgr., Long Island Operations, New York Water Service Corp., 11 Smith St., Merrick, N.Y. (Oct. '45) *M*

Bonyun, Richard E., Gen. Supt. & Chief Engr., Passaic Valley Water Com., 1525 Main Ave., Box 203, Clifton, N.J. (Oct. '35)

Brensley, Albert A., San. Engr., 310 S. Linden Ave., Decatur, Ill. (Jan. '48)

Brown, M. G., *see* Republic Steel Corp.

Burns, H. L., Mgr., Wholesale Supply Co., 181 N. Sunset Dr., Jackson, Miss. (Oct. '50)

Charles, Paul Lamont, Sales Engr., Walsh & Charles, Ltd., 1677 Portage Ave., Winnipeg, Man. (July '47)

Chevedden, Carl E., Filtration Engr., Water Purif. Div., 8334 Michigan Ave., Chicago 19, Ill. (July '44) *P*

Cole, B. G., Supt., Waterworks Dist. No. 3, Box 489, Pineville, La. (Oct. '39) *MP*

Collins, T. H., Birmingham Water Works Board, 2114—1st Ave., N., Birmingham 3, Ala. (Jan. '46) *MPR*

Columbia Water & Light Dept., Fred F. Williams, Director, Municipal Bldg., Columbia, Mo. (Corp. M. Jan. '51) *M*

Columbus Munic. Water Utility, Richard L. Thayer, Mayor, Columbus, Ind. (Corp. M. July '50)

Cooke, Harold D., Civ. Engr., 113-15—84th Ave., Richmond Hill 18, N.Y. (Jan. '48) *MP*

Cory, R. W., *see* Pendleton (Ind.) Water Co.

Covington, City of, Maurice Holland, Supt., Light & Water, City Hall, Covington, Ind. (Corp. M. Apr. '43)

Crachi, Domenico, Jr., Civ. Engr., 142 Ontario Ave., Massapequa, N.Y. (Oct. '49) *R*

Craftsman Painting Service, Kenneth P. Sullivan, 7654 S. Park Ave., Chicago 19, Ill. (Assoc. M. Jan. '50)

Craig, Charles P., 193 E. Cliff St., Somerville, N.J. (Jan. '42) *P*

Cromwell, C. E., *see* De Laval Steam Turbine Co.

Danielson, Alton, *see* North St. Paul (Minn.) Utilities Dept.

De Laval Steam Turbine Co., C. E. Cromwell, Mgr., Commercial Sales Div., Trenton 2, N.J. (Assoc. M. Nov. '17)

Delavan Water Com., R. H. Mitchell, Supt., Delavan, Wis. (Corp. M. June '23)

Denney, Howard M., *see* Maywood (Ill.)

Earl, Thomas C., American Water Works Service Co., 121 S. Broad St., Philadelphia 7, Pa. (Jan. '47) *MP*

Erickson, Edwin T., Prin. Asst. Engr., Div. of Water, 101 City Hall Annex, Newark, N.J. (Jan. '48)

Erickson, Frederick K., 9912 Thornwood Rd., Kensington, Md. (Apr. '44) *PR*

Eschenbrenner, Irvin G., Purif. Foreman, St. Louis County Water Co., 6600 Delmar Blvd., University City 5, Mo. (July '50)

Evansville Water Works Dept., Board of Trustees, Joseph Bastian, Evansville 9, Ind. (Corp. M. May '06)

Ewbank, Norman M., Jr., Bottlers' Service Dept., The Coca-Cola Co., Drawer 1734, Atlanta 1, Ga. (Oct. '49) *P*

Fishtein, Max, Dist. Repr., Davis Mfg. Co., Room 642, 53 W. Jackson Blvd., Chicago 4, Ill. (Dec. '27) *MPR*

Forgey, Carl S., Eng. Assoc., East Bay Munic. Utility Dist., 2127 Adeline St., Oakland 7, Calif. (June '33) *M*

Fortin, Joseph O., Etowah, N.C. (July '42)

Fraser, Sam D., Mgr., Del Mar Utilities, Box 256, Del Mar, Calif. (May '26)

Friedrichs, C. C., Dist. Mgr., Wallace & Tiernan Co., Inc., 1107 McIlhenny St., Houston 2, Tex. (Jan. '46)

Furrey, William P., Chairman, North Jersey Dist. Water Supply Com., 5 Colt St., Paterson, N.J. (Oct. '51) *MR*

Garman, Glenn J., *see* Lafayette (Ind.) Water Works

Glenwood Springs, City of, W. E. Ralls, City Mgr., Glenwood Springs, Colo. (Corp. M. Oct. '48) *MR*

Golder, Hugh C., Mng. Director, Economic Water Softeners, Ltd., Warwick Rd., Greet, Birmingham 11, England (July '37)

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(*Continued from page 42*)

Goldman, Ernst E., Engr., Knappen-Tippett-Abbett-McCarthy, Port-au-Prince, Haiti (Apr. '44)

Gonzalez del Valle, M. A., Civ. Engr., 523 Ave. 26, Alturas del Vedado, Havana, Cuba (Oct. '48)

Gorder, Zenno A., City Engr., City Hall, La Crosse, Wis. (Oct. '48) *M*

Grandfield, Norman A., Mgr., Public Utilities Com., Wellington & Dickson Sts., Galt, Ont. (Apr. '48)

Groshart, A. F., *see* Julesburg (Colo.)

Hagood, Howard, Jr., Howard Hagood Co., Box 175, Bellaire, Tex. (Oct. '46) *P*

Hargleroad, James C., ORDLY-S, Ordnance Ammunition Center, Joliet, Ill. (Apr. '46) *P*

Hatch, B. F., 3042 Woodbine Pl., Columbus 2, Ohio (Jan. '47) *MPR*

Holland, Maurice, *see* Covington (Ind.)

Holt, Stewart, *see* Midland (Ont.) Public Utilities Com.

Howard, Edward, San. Engr., State Dept. of Health, 14 Hartford Ave., Glens Falls, N.Y. (Jan. '51)

Hubbard, Robert L., Water Works & Drainage Contractor, 131 S. Bellevue Ave., Langhorne, Pa. (Apr. '46)

Jemian, S. C., H. A. Kuljian Corp., 1200 N. Broad St., Philadelphia 21, Pa. (Jan. '47)

Jones, T. E., San. Engr., Aro, Inc., 320 S. Polk St., Tullahoma, Tenn. (Jan. '40) *M*

Julesburg, Town of, A. F. Groshart, Water Supt., Julesburg, Colo. (Corp. M. July '37) *M*

Kahoe, W. Howard, *see* Yellow Springs (Ohio)

Kaplan, Morris, Sr. San. Engr., South Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago, Ill. (Apr. '47) *P*

Katz, Sol J., Dist. Mgr., Koppers Co., 727 E. Gage Ave., Los Angeles 1, Calif. (Oct. '50)

Kay, George F., *see* White Rock Corp.

Keatley, Charles R., Chief, San. Eng. Branch, Engr. Research & Development Laboratories, Fort Belvoir, Va. (Jan. '40) *P*.

Kennedy, James W., Hydr. Engr., Canadian Ingersoll Rand Co., Ltd., 1057 Bay St., Toronto 2, Ont. (Apr. '43)

Kennedy, W. H., Mgr. of Utilities, Box 86, Newton, Tex. (Jan. '46) *M*

Kershaw, Neil F., 117 Upnor Rd., Baltimore 12, Md. (Jan. '37) *P*

Kingsley, Don F., *see* Newburgh (N.Y.) Water Dept.

Kiniry, John J., *see* New Britain (Conn.) Water Board

Kirk, Jack W., Field Engr., International Water Supply Ltd., 156 Colborne St., E., Oakville, Ont. (Apr. '44) *PR*

Kishel, Edward F., *see* Bettenburg, Townsend & Stolte

Klingman, Fred W., Asst. Supt., Division Ave. Filtration Plant, W. 32nd St. & Division Ave., Cleveland 13, Ohio (Jan. '51)

LaDuex, John B., *see* Russell (Kan.)

Lafayette Water Works, Glenn J. Garman, Supt., Lafayette, Ind. (Corp. M. Dec. '37) *M*

Lamb, Clarence Francis, Civ. Engr. & Partner, Waterman Eng. Co., 480 Atlantic Ave., Lakewood 5, R.I. (Apr. '51) *MR*

Lewis, William M., Layne-New York Co., Inc., 92 Liberty St., New York, N.Y. (Jan. '37)

Lupien, Leo, City Mgr., City Hall, Cap de la Madeleine, Que. (Apr. '49)

Lynch, James Gillinder, Field Instructor, Texas Engineering Extension Service, 7021 Ave. F, Houston 11, Tex. (Jan. '51) *P*

MacDougall, Hugh, Chief Design Engr., Hydrotechnic Corp., 665—5th Ave., New York, N.Y. (Oct. '47)

MacKenzie, J. M., *see* Port Colborne (Ont.)

Marion, Town of, James W. Ritter, Jr., Town Engr., Marion, Va. (Corp. M. Oct. '44) *M*

Marsh, John A., Supt., Nottingham Filtration Plant, 19624 Chagrin Rd., Euclid, Ohio (Apr. '37) *P*

Martin, Earl, Southern California Water Co., 111212 E. Live Oak Ave., Arcadia, Calif. (Oct. '40) *M*

Martin, N. V., Gen. Mgr., The Bournemouth & Dist. Water Co., Alderney Water Works, Winton, Bournemouth, Hants., England (Oct. '49) *MPR*

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Martinez, Sergio S., Civ. Engr., Ave. Victoria No. 35 esqunia a Bruseals, Rpto. Kohly, Marianao, Havana, Cuba (July '38)

Mason, Ovid William, 13 S. 2nd St., Highland Park, Ill. (Oct. '46)

Maxwell, William A., Engr., Toronto Township, Cooksville, Ont. (Jan. '39) *M*

Maywood, Village of, Howard M. Denney, Supt. of Public Works, 125 S. 5th Ave., Maywood, Ill. (Corp. M. Apr. '49)

McCullough, O. E., Jr., *see* Pittsburgh Coke & Chem. Co.

McGrann, John H., 4536 Broadway, Kansas City, Mo. (Jan. '41)

Metallizing Eng. Co., Inc., Howard Vanderpool, Mgr., Sales Eng., 38-14—30th St., Long Island City 1, N.Y. (Assoc. M. July '51)

Midland Public Utilities Com., Stewart Holt, Secy.-Treas., Box 548, Midland, Ont. (Corp. M. Mar. '27) *MPR*

Miller, Charles R., Village Mgr., Village Hall, Winnetka, Ill. (Oct. '41) *M*

Mitchell, R. H., *see* Delavan (Wis.) Water Com.

Morrill, Arthur B., Instituto Nacional de Obras Sanitarias, 2nd Piso, Edificio Las Mercedes, Caracas, Venezuela (Oct. '25) *P*

Mortensen, F. C., Army Hospital, Camp Carson, Colo. (Apr. '40) *P*

Murry, I. S., *see* Saticoy (Calif.) Water Co.

New Britain Water Board, John J. Kiniry, Chairman, 27 W. Main St., New Britain, Conn. (Corp. M. Apr. '47)

Newburgh Water Dept., Don F. Kingsley, Supt., 79-81 Dubois St., Newburgh, N.Y. (Mun. Sv. Sub. Apr. '49)

Nickerson, Howard L., *see* Bakelite Co.

North St. Paul Utilities Dept., Alton Danielson, Supt., North St. Paul, Minn. (Corp. M. Apr. '46)

Ocala Water Dept., E. C. Shreve, Jr., 512 Orange Ave., Ocala, Fla. (Corp. M. Apr. '38)

Osborn, L. C., Cons. Engr., R. S. Tipton & Assoc., 601 Insurance Bldg., Denver 2, Colo. (Oct. '46)

Owens-Corning Fiberglas Corp., John B. Roadhouse, Anti-Corrosion Products Sales Div., Toledo 1, Ohio (Assoc. M. Oct. '46)

Pappmeier, Louis E., Cons. Engr., Pappmeier Eng. Co., 220 N. Chambers St., Galesburg, Ill. (Jan. '45) *P*

Paris Public Utilities Com., C. A. Veigel, Secy.-Treas., Box 970, Paris, Ont. (Corp. M. Jan. '42)

Pavanello, Renato P., Adviser to East Bengal Govt., World Health Organization, 71 Circuit House, Dacca, East Pakistan (Oct. '49)

Pendleton Water Co., R. W. Cory, Supt., Pendleton, Ind. (Corp. M. Jan. '49)

Perry, Aubrey H., Supervising Engr., Public Health Eng. Div., Dept. of National Health & Welfare, 1110 W. Georgia St., Vancouver, B.C. (Mar. '31) *PR*

Pettengill, C. L., Pres., Filter-Soft Corp., 12911 Artesian Ave., Detroit 23, Mich. (Jan. '49)

Pittsburgh Coke & Chem. Co., O. E. McCullough, Jr., Protective Coatings Div., 1905 Grant Bldg., Pittsburgh 19, Pa. (Assoc. M. July '49)

Pohl, Charles A., Bogart & Pohl, 420 Lexington Ave., New York 17, N.Y. (Jan. '43) *PR*

Port Colborne, Munic. Council of the Town of, J. M. MacKenzie, Town Engr., Port Colborne, Ont. (Corp. M. Jan. '47) *MP*

Ralls, W. E., City Mgr., Glenwood Springs, Colo. (Apr. '39) *MPR*

Ralls, W. E., *see* Glenwood Springs (Colo.)

Ratcliffe, Richard G., Repr., James B. Clow & Sons, 1755 Ridgeview Rd., Columbus 12, Ohio (Jan. '50)

Reichman, Irving, 1084 Rhinelander Ave., New York 61, N.Y. (Apr. '44)

Republic Steel Corp., M. G. Brown, Mgr., Pipe Sales Div., Republic Bldg., Cleveland 1, Ohio (Assoc. M. Apr. '32)

Rice, Cyrus William, Chairman, Board of Directors, Cyrus William Rice Co., Inc., 17 Noble Ave., Pittsburgh 5, Pa. (Oct. '24)

Ricketts, H. Palmer, Porter, Barry & Switzer, Cons. Engrs., Box 1667, Baton Rouge, La. (Jan. '46) *P*

Ritter, James W., Jr., *see* Marion (Va.)

Rizzi, Joseph N., Jr., Asst. Engr., Malcolm Pirnie Engrs., 25 W. 43rd St., New York 18, N.Y. (July '50)

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Roadhouse, John B., *see* Owens-Corning Fiberglas Corp.

Robertson, D. A., Jr., 19 DeWitt St., Belleville, N.J. (Oct. '48)

Rotthaus, Helen (Mrs.), State Dept. of Health, State Office Bldg., Phoenix, Ariz. (Apr. '48) *Fuller Award '50.*

Ruggles, Roy, Supt., Constr. & Distr., 651—14th St., N.W., Atlanta, Ga. (Apr. '48)

Russell, City of, John B. LaDuex, City Manager, Russell, Kan. (Corp. M. Apr. '51)

Saticoy Water Co., I. S. Murry, Manager, Box 275, Saticoy, Calif. (Corp. M. Apr. '43)

Schamberger, Karl H., Sr. Assoc. Engr., Bureau of Water Supply, Municipal Bldg., Baltimore 2, Md. (Jan. '42) *M*

Shand, Harold, Engr., Greater Winnipeg Water Dist., 455 Ellice Ave., Winnipeg, Man. (Jan. '45)

Shaw, Percy A., Supt., Water Works, 281 Lincoln St., Manchester, N.H. (June '34) *Director '47–'50. MPR*

Sherrill, Miles O., Prin. Engr., Maurice L. Miller, Cons. Engr., 400 McDowell Bldg., Louisville, Ky. (Oct. '49)

Shreve, E. C., Jr., *see* Ocala (Fla.) Water Dept.

Simonton, L. R., Supt., Water & Sewage Treatment Dept., Griffin, Ga. (Apr. '34) *P*

Sloan, Garrett, 1213 Ramblewood Rd., Baltimore 12, Md. (Apr. '42)

Smith, Edward Gerald, 2922 Fair Park Blvd., Little Rock, Ark. (Oct. '48) *MPR*

Smith, Sidney B., Alkali Products Specialist, Westvaco Chem. Div., 405 Lexington Ave., New York 17, N.Y. (July '51) *P*

Soffe, Benjamin F., 1644 N. Crescent Heights Blvd., Los Angeles 46, Calif. (Apr. '44)

Sopp, George C., Asst. Mgr. & Joint System Head, Dept. of Water & Power, 207 Broadway, Los Angeles 12, Calif. (Apr. '36) *Fuller Award '45. M*

Speer, Ralph E., City Mgr., Sault Ste. Marie, Mich. (July '47)

Stewart, Fredrick Choate, Cons. Engr., 1007 Dominion Bank Bldg., Vancouver 3, B.C. (Jan. '45) *MPR*

Sullivan, Kenneth P., *see* Craftsman Painting Service

Summers, Oliver W., Development Engr., Indianapolis Water Co., 113 Monument Circle, Indianapolis 6, Ind. (Apr. '50)

Swanger, G. F., 123 W. Merry Ave., Bowling Green, Ohio (Oct. '47) *P*

Synan, John F., Mgr., Product Development, Mathieson Chem. Corp., Mathieson Bldg., Baltimore 3, Md. (Jan. '45) *P*

Taggart, Robert S., 14 Girard Pl., Maplewood, N.J. (Apr. '37) *P*

Talbot, Leland A., 2626 S. Mosley St., Wichita, Kan. (Apr. '51) *MR*

Telfair, John S., Jr., Smith & Gillespie, Engrs., Box 1048, Jacksonville 1, Fla. (July '48) *PR*

Tetzlaff, Frank, 330 Gilbert St., Ridgewood, N.J. (Jan. '36) *P*

Thayer, Richard L., Columbus (Ind.) Munic. Water Utility

Thomson, R. D., Office Mgr., Medical Centre, 180 Portland St., Dartmouth, N.S. (Apr. '48)

Tomlinson, W. S., 516 Harden St., Columbia, S.C. (July '37)

Tomlinson, Walter John, 377 High St., Norwood, N.J. (July '38) *P*

Townsend, Hal C., Repr., Worthington-Gamon Meter Div., Worthington Pump & Machinery Corp., 1975 Eager Rd., R.R. 5, Howell, Mich. (Jan. '38)

Treanor, Earl E., Owner, Earl E. Treanor Eng. Co., 2821 W. 91st St., Kansas City, Mo. (Jan. '44) *P*

Trubnick, Eugene H., R.F.D. 1, Box 265, New Brunswick, N.J. (Apr. '44) *P*

Turnbull, Donald O., Cons. Engr., 105 Prince William St., St. John, N.B. (July '49)

Van Arnum, William I., Chem. Engr., 2392 Seneca Rd., Westfield, N.J. (Feb. '22)

Van Blarcum, B. H., Water Supt., 119 N. 3rd St., Manhattan, Kan. (Apr. '44) *MP*

Vanderpool, Howard, *see* Metallizing Eng. Co.

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"In water we drink ninety per cent of our maladies. When ozone is added the microbes are killed and the toxins are burned."
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If Pasteur could see a modern Welsbach Ozone water treatment plant, he would add, ". . . objectionable odors, tastes and colors are eliminated."
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PIONEERS IN CONTINUING OZONE RESEARCH

(*Continued from page 48*)

Van Wickler, Fred R., *see* West Hempstead-Hempstead Gardens (N.Y.) Water Dist.

Veigel, C. A., *see* Paris (Ont.) Public Utilities Com.

Ware, Stanton J., 628 Burlington Ave., Billings, Mont. (July '48)

Weagraff, Charles R., Great Valley, N.Y. (July '35) *MP*

Webb, Clark D., Dist. Mgr., Pacific States Cast Iron Pipe Co., 6399 Wilshire Blvd., Los Angeles 48, Calif. (Oct. '43) *MPR*

Werner, Bernard L., Deputy Water Engr., Bureau of Water Supply, 4220 Oakford Ave., Baltimore 15, Md. (Oct. '46)

West Hempstead-Hempstead Gardens Water Dist., Fred R. Van Wickler, Supt., 575 Birch St., West Hempstead, N.Y. (Corp. M. Jan. '50)

White, George W., The Harwood Beebe Co., Box 2283, Station A, Spartanburg, S.C. (Dec. '24) *P*

White Rock Corp., George F. Kay, Vice-Pres., Quality Control Lab., Foot of Van Dyke St., Brooklyn, N.Y. (Corp. M. Apr. '50) *P*

Whitley, F. H., MSC, 0-31106, Medical Section, Hq. 6th Army, Presidio, San Francisco, Calif. (Jan. '39) *PR*

Wilbur, Conrad C., Gannett Fleming Corddry & Carpenter, 600 N. 2nd St., Harrisburg, Pa. (Feb. '24)

Williams, Fred F., *see* Columbia (Mo.) Water & Light Dept.

Williams, Walter E., Box 909, Cheshire, Conn. (Apr. '50)

Williamson, R. C., Vice-Pres., Alchem, Ltd., Box 260, Burlington, Ont. (July '37)

Williams-Smith, F. T., 18 Albion St., Port-of-Spain, Trinidad (Jan. '48) *M*

Wilmot, W. G., Supt., Boise Water Corp., Boise, Idaho (Apr. '44)

Woods, Charles E., Bookkeeper, New Haven Water Co., 100 Crown St., New Haven, Conn. (Jan. '51) *M*

Yellow Springs, Village of, W. Howard Kahoe, Village Mgr., Box 226, Yellow Springs, Ohio (Apr. '49) *MR*

Young, Robert H., Cons. Engr., Box 1026, Jackson, Miss. (Apr. '49) *MPR*

Condensation

Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; S.I.W.—Sewage and Industrial Wastes; W.P.A.—Water Pollution Abstracts (Great Britain).*

ANNUAL REPORTS

Erie (Pa.) Bureau of Water. Annual Report (1950). Progress on expansion program included installation of six 2-mgd filters, 12-mgd high-service and 20-mgd low-duty and low-service pumps. Constr. of mains and services reached all-time high. Assets: current, $737,221; fixed, $11,369,725 (cost, $16,689,499; depn. reserve, $5,319,774); total, $12,120,267. Liabilities: current, $16,335; bonds, $1,291,000; investment and surplus, $10,812,931 ($249,138 increase). Receipts: water sales, $1,119,103; other, $209,345. Expenditures of $1,844,566 include: interest, $41,286; bonds retired, $95,000; and capital outlay, $860,098. Cost/mil gal: collection, storage, filtration, pumping, and depn. for these items, $36.85; admin., distr., etc., and depn., $40.45; interest, $3.04; debt retirement, $7.00; constr., $63.34; total, $150.68. Free water to city, $76,802. West Filter Plant and Chestnut St. Plant data, resp.: water filtered, $15.40 and $21.41 mgd; alum, 6 and 7 ppm; Cl, 7.19 and 2.98 lb/mil gal; activated carbon, 1.55 and 1.33 lb/mil gal; NH_3, 0.64 lb/mil gal (West Plant only); wash water, 1.35 and 2.11%; bact. count reduced from mo. avgs. of 38–1,131 and 106–1,497/ml to 0; *Esch. coli* to 0 in 10 ml; turbidity from mo. avgs. of 5–32 and 5–33 ppm to 0. Pop. served 148,000. Consumption: max., 50.10; avg., 37.20 mgd; 251 gpcd. Mains, 333 mi; hydrants, 1,812; gates, 5,086; services, 37,876 (32,315 active); avg. service cost, $52.04; meters, 1,676; services metered, 5.19%; receipts from metered water, 48.75% of total. Chestnut St. Pumping Station data: avg. dischg. head, 268 ft; cost of coal/mil gal pumped, $10,996; gal pumped/lb coal, 293. Meter rates (nondomestic) 6–20¢/1,000 gal, with min. bill varying with service size—outside city 25% higher. Chestnut St. plant consists of 60-in. c-i and steel intake extending 5,100 ft into L. Erie and terminating in crib with 22-in. min. water cover (capac. 36 mgd.); 24-mil gal settling basin providing 24-hr retention, sixteen 2-mgd rapid sand filters and 0.7 mil gal clear well. West Plant intake 72-in. steel, terminating in crib with 22-in. min. water cover (70 mgd capac.). Filter plant capac. 16 mgd, in emergency 24 mgd. Distr. storage: low- and high-service reservoirs, 33 and 10 mil gal, resp.; 100,485-gal elev. tank; and 300,000-gal standpipe.—*R. E. Thompson.*

Richmond (Va.) Dept. of Public Utilities. Annual Statistical Summary (Year Ended June 30, 1951). Two 85-mil gal settling basins; 22 filters, area and capac. 23,716 sq ft and 66 mgd, resp.; pumping capac., low-lift, 100 mgd; aerator pumps, 124; low-service, 96; high-service, 92; reservoir storage, 46 mil gal; elev. storage, 4.1 mil gal in four tanks; largest 2 mil gal. Water treated 29.4 mgd; avg. filter run, 125 hr; wash water, 1%. Activated carbon applied to filters at beginning of run; addnl. amts. added at 24-hr intervals: if more than 10 lb/mil gal required, excess added before

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coagulant. Chem. used before filtn.: $CuSO_4$, alum, chlorinated copperas, Cl (avg. 22.4 lb/mil gal) and activated carbon (avg. 4.1 lb/mil gal), after filtration, NH_3, Cl, and CaO, avg. dosages 4.0, 15.1 and 38.1 lb/mil gal, resp. Avg. turbidity reduced from 35 (max. 650) to 0.1 ppm. (max. 0.2), color from 65 (max. 280) to 2 (max. 3), 37 C bact. count from 1,699 (max. 40,000) to max. 2. Avg. filtered water pH 8.7. No presump. pos. coliform tests in 100-ml portions of treated water. Mains, 565 miles; hydrants, 3,334; active meters, 56,259; meters repaired, 9.2% of those in service. Rates: $1.00 for first 600 cu ft or less/mo. (min. bill); 6–15¢ per 100 cu ft above that amt. Outside city: 6.5–32.5¢ per 100 cu ft; min. monthly bill, $2.10. Pop. 231,000; customers, 56,259; customers/mile of main, 99.5; consumption, 122 gpcd.—*R. E. Thompson.*

Burnaby (B.C.). Annual Report (1950). W.W. Inf. Exch.—Can. Sec. AWWA, **8**:E:5:9 (Dec. '51). Avg. consumption, 6.85 mgd. Mains, 215 miles, of which 31%, 4 in., and 26%, 6 in. Services installed, 1,250; frozen, 267. Hydrants installed, 58.—*R. E. Thompson.*

Dauphin (Man.). Annual Report (1950). W.W. Inf. Exch.—Can. Sec. AWWA, **8**:E:4:7 (Dec. '51). Pop. served, 4,000. Source of supply, Edwards L. and Edwards Creek; chlorinated, 1 ppm avg. Reservoir capacs.: upper, 5 mil gal; lower, 14.7. Avg. consumption, 0.78 mgd, 196 gpcd; metered, 25.2% of total. Mains, 15 miles; hydrants 119, valves 233, services 1,-

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060, metered 101. Revenue 52,318, incl. hydrant rentals, \$5,600 (\$50 each); expenditures, \$56,288; including debenture and sinking fund charges, \$20,414; sewage disposal, \$11,182; and deficit, \$3,970. Capital assets, \$769,700; debentures, \$205,500; sinking fund, \$13,528; net indebtedness, \$191,972.—*R. E. Thompson.*

Chatham (Ont.). Annual Report (1950). W.W. Inf. Exch.—Can. Sec. AWWA, **8**:E:6:10 (Dec. '51). Pop. served, 23,700. Supply from Thames R., purified by double coagn. (spiral-flow mixing, 30 min), pressure filtration and Cl-NH_3 disinfection. Filters: 11 units; total area, 1,451 sq ft; total capac., 4.18 mgd (U.S.). Land purchased for new filter plant. Pumping capac.: low lift, 12 mgd; high lift, 11. Consumption: max., 6.52 mgd; avg., 4.12; 171 gpcd. Avg. chem. dosage: alum, 24 ppm; ammonium sulfate, 0.37 and 0.3 ppm before and after filtration, resp.; Cl, 1.37 and 0.31 ppm before and after filtration, resp. Services, 6,082; persons/service, 3.9; mains, 59 miles; ft of main per service, 51, per capita, 17.4; hydrants, 341. Receipts, \$217,987, include: hydrant rentals, \$15,280; disbursements, \$183,767; surplus, \$33,690.—*R. E. Thompson.*

Singapore Water Dept. Annual Report (1949). Three catchment areas on the island and 3 in Johore were patrolled, supervised, and improved where possible but unrest in Johore restricted activity there. Rainfall on catchment areas 62.9–111″, of which 36–52% appeared as runoff, total draught being 83% and upwards of latter. *Cosmaria* troublesome in Nov., but color of water not appreciably affected. Woodleigh slow sand filter plant gives excellent results but area and labor excessive. Gunong Pulai mechanical filters cannot deal satisfactorily with more than 12 mgd because of inadequate conditioning facilities; must be operated at 16 mgd and hence phys. qual. of effluent impaired. Research in progress at Bukit Timah exptl. filter plant. Woodleigh plant data: avg. rate of filtration 4.28 gpd/sq yd; avg. run 18 days; avg. chem. dosages, ppm: before sedimentation, lime 5.29; after filtration, lime 9.48; chloride of lime—1.65, Cl—0.51, NH_3—0.17. Bukit Timah filters: avg. water filtered 13,265 gal/sq ft/run; avg. chem. dosages, ppm: before sedimentation, lime—4.36, Cl—0.48; before filtration, chloride of lime—1.71; after filtration, Cl—0.69, NH_4Cl—0.48, NH_3—0.22, lime—3.22, filtered water 98.72% of raw. At Gunong Pulai filters, alum, soda ash, and limestone applied before sedimentation; avg. of 0.31 ppm Cl and 0.10 NH_3 before filtration, and 6 ppm lime, 1.35 chloride of lime, and 0.34 Cl after filtration. Wash water 8.34%. Midge fly larvae again evident in Woodleigh clearwater tank which was subsequently cleaned and chlorinated. Distr. system patrol and waste detection facilitated by radio communication. Whole island surveyed for waste and 37,969 premises inspected; nearly 0.5 mgd being saved. Salt water system supplied 163 mil gal for town cleansing; should be discontd. when fresh water available. Consumption: max. 34.83 mgd, avg. 31.30, 32.9 gpcd. Accounted-for water, 92.98%. Water cost per 1000 gal: fresh water \$0.5588, salt water \$0.2002. Income per 1000 gal sold \$0.6745. Capital expenditures to date, \$46,684,744; depn. fund, \$1,605,041; general reserve, \$1,722,928. Income from water sales, \$7,040,936; operating expense, \$5,645,605; extraordinary receipts, \$1,061,540; capital expenditures from revenue, \$2,334,334; surplus, \$122,537. Avg. bact. count on agar: raw water, 253; chlorinated water, 58; tap supplies, 65; service reservoirs, 62. Lactose fer-

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menters absent in 100, 99.3 and 98.8% of 100-ml portions of last 3, resp.; pH, 6.1, 7.5, and 7.4, resp.; free Cl, 0.06, 0.02, 0.02, resp. Mains 520 miles, hydrants 4,236 (89 salt water), meters 41,210 (100%), consumers 950,000.—*R. E. Thompson.*

CHEMICAL ANALYSIS

Lead, Copper, and Zinc in Drinking and Tap Water. II. O. Högl & H. Sulser. Mitt. Gebiete Lebensm. Hyg. (Swiss), **42**:286 ('51). A method for the detn. of Pb, Zn, and Cu in water with dithizone is described. The heavy-metal content is small in well water, but increases in tap and boiler water and is highest in cold stagnant tap water.—*CA*

Infrared Spectrophotometric Determination of Oil and Phenols in Water. R. G. Simard, Ichiro Hasegawa, William Bandaruk, & C. E. Headington. Anal. Chem., **23**:1384 ('51). A sensitive, accurate infrared method is described for detg. small amts. of oil and phenols in water. The method for phenols is based on bromination of the phenols, extraction of the resulting bromides from H_2O with CCl_4, and measuring optical density of extraction at 2.84 μ where absorption is due to OH vibration when intramolecular H bonding of the Br and OH groups takes place. The oil detn. is based on optical density measurement of the same extraction at the CH_3, CH_2, and CH stretching frequencies in the region of 3.4 μ. The method for oil is sensitive to 0.1 ppm. Less than 10 parts per billion of phenols can be detd. with reasonable accuracy. Accuracy is not affected by the volatility of the materials.—*CA*

The Determination of Oxygen Content of Water. Rezso Maucha. Hidrol. Közlöny (Hung.), **29**:343 ('49). The modified Winkler-method (cf. *Arch. Hydrobiol.*, **1944**), a semimicro method, proved to be suitable when testing pure natural waters contg. insignificant amts. of org. substances, H_2S, polythionic acid, or nitrites which disturb the reaction. When, however, natural waters contg. a large quantity of reducing substances, or natural waters contg. sewage water, or sewage and waste waters are to be investigated, a special procedure must be applied, based upon the principle proposed first by Bruhns. Fill test tubes (equipped with tight glass stoppers) with the water to be investigated, add 0.05 g solid NaOH and 0.05 g cryst. $MnCl_2$, insert the stopper, shake the tube, and let stand for 5–10 min with the stopper closed. Remove the stopper, fill the tube with 1.0–1.5 ml concd. K_2CO_3 soln. without stirring up the ppt. developed in the meantime, insert the stopper again, shake, let stand vertically for a few min, remove the stopper and pass through cotton in a Winkler-filter, wash the ppt. with 25–30 ml 3% $KHCO_3$ soln., pour 3 ml 5% KI soln. on the ppt., dissolve the ppt. with 1–2 ml of 50% H_2SO_4, cover the filter with a watch glass until gas development ceases, wash with water, and titrate the filtrate with 0.005 or 0.002 N $Na_2S_2O_3$ soln. The O_2 content of the water is calcd. by means of the formula $O_2 = (n \times v \times f \times 0.04 \times 1000)/V$ mg, where n denotes the no. of drops of $Na_2S_2O_3$ soln. required, v the vol. of one drop in ml, f the factor (titer) of thiosulfate soln., and V the vol. of the test tubes used. This formula is valid for 0.005 N thiosulfate soln. In a 0.002 N soln. the no. 0.04 should be replaced by 0.016. The method is suitable as well for the detn. of the biochem. O_2 demand of sewage waters and natural waters contamd. with sewage—*CA*

Volumetric Analysis of Sulfates in Water. H. Mestayer. L'Eau (Fr.),

(*Continued on page 60*)

(*Continued from page 58*)

38:81 ('51). To the sample add 1 drop of concd. HCl and a slight excess of 0.01 *N* $BaCl_2$. Evap. to dryness, take up in 50% aq. alc., add 2 mg of indicator mixt. contg. 6.25 mg Victoria Blue, 50 mg. Ba rhodizonate, and 5.12 g of ignited talc and titrate the excess Ba (with $(NH_4)_2SO_4$) in 50% EtOH by adding the reagent dropwise with stirring until the violet color begins to fade. The end point is reached when the color is a very pale grayish yellow, turning to green in a few min. Many ions interfere but are not usually present in drinking water. Phosphate in boiler water should be removed or a correction applied.—*CA*

Determination of Sulfate in Drinking and Mineral Waters. Károly Sarló. Hidrol. Közlöny (Hung.), **29**: 331 ('49). Remove hardness by treating the water sample with NaOH (or possibly with Na_2CO_3) at 75 C, cool, titrate 100 ml soft water with 1.0 *N* HCl in the presence of a few drops of 0.1% methyl orange, introduce a few fragments of pumice stone, remove CO_2 by boiling for 3 min, cool with tap water, add a few drops of Br water to destroy the color of methyl orange, add 0.5 ml of a 2.0% neutral soln. of phenolphthalein in EtOH, drop in 0.1 *N* NaOH until a stable red color appears, let stand for 2 min, remove color by adding a few drops 0.1 *N* HCl, add one more drop of HCl, and titrate with 0.1 *N* K palmitate in PrOH, prepd. according to Winkler, until a stable pink color appears. If the water sample is properly softened, it should not require more than 0.2–0.3 ml. Now add 2 drops 0.1 *N* HCl, drop in 5 ml 0.1 *N* $BaCl_2$, and observe the time required for sedimentation of the ppt. formed. If sedimentation occurs within 2 min, add 4 ml $BaCl_2$ soln., let stand for 30 min, filter through a thin filter paper, and wash 3 times with 4 ml water free of CO_2. Add to the filtrate 0.1 *N* NaOH free of CO_2 until a stable red color appears, wait for 2 min, remove color by adding a few drops 0.1 *N* HCl, add another drop HCl, and titrate with K palmitate soln. until a stable pink color appears. Now 0.1 ml should be deducted from the no. of ml consumed in the titration, the no. of ml of $BaCl_2$ soln. used must also be deducted, and the result must be multiplied by 4.803 to obtain the sulfate content of the water in mg. Blank tests should be run to establish the K palmitate consumption of the reagents used. A detn. takes 60 min. Usually a 100-ml water sample is satisfactory for a test. The results obtained are accurate except for waters contg. 30–60 mg/l. sulfate where errors are relatively higher.—*CA*

Relation Between the Temporary Hardness of the Neuchâtel Lake Water and the Conductibility. C. Portner. Mitt. Gebiete Lebensm. Hyg. (Swiss), **42**:312 ('51). A formula for the relation between temporary hardness and conductibility has been established. Thus, the temporary hardness can be detd. quicker and more accurately by measuring the conductibility.—*CA*

Determination With Potassium Stearate of the Total Hardness in Waters. Szilard Papp & Imre Farkas. Hidrol. Közlöny (Hung.), **30**:373 ('50). The drawback inherent in the Winkler method for mass investigations is the relatively high cost of palmitic acid. K stearate is suitable for such detns. The principle of the method is based upon the fact that stearic acid forms insol. stearates with the Ca and Mg ions of the water. The reagent is prepd. as follows: Mix 10 g stearic acid, 1.0 g phenolphthalein, 800 ml of MeOH, heat slightly until the solids dissolve, neutralize with 4%

(*Continued on page 62*)


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(*Continued from page 60*)

KOH in MeOH, dil. to 1 l. with MeOH, and adjust with a 0.05 *N* $BaCl_2$ soln. of 0.780 titer no. For this purpose 10 ml of this $BaCl_2$ soln. should be dild. with distd. water (which has been boiled) to 100 ml and titrated with K stearate soln.; a well-adjusted stearate soln. should use 10 ml for the titration. The actual detn. of total hardness is performed by titrating the 100-ml water sample used for the detn. of alky. (slightly brown colored, owing to methyl orange used in the detn. of alky.) with K stearate soln. until a pink color appears. The no. of ml required gives directly the total hardness value in German degrees. The results obtained by using the stearate method were identical with those obtained by the Winkler palmitate method.—*CA*

The Measurement of Turbidity in Water. A. G. KNIGHT. J. Inst. Wtr. Engrs. (Br.), **4**:449 ('50). It is recommended that a photoelec. method be used for the detn. of turbidity. The basic measure of turbidity should be a suspension such that a depth of 150 mm would absorb 10% of the light falling on it and that this suspension should be given the value of 10. Light extinction is measured without the use of an arbitrary instrument such as the Jackson Turbidimeter or the necessity of weighing the material in suspension. A method of calibration is proposed that is a move toward a purely fundamental standard. **Reply.** R. W. AITKEN and D. MERCER. *Ibid.,* **5**:328 ('51). Calcns. give results not far from the actual suspension values obtained. Some galvanometers used with photometric colorimeters are calibrated directly or a calibration curve can be readily produced. **Reply.** A. G. KNIGHT. *Ibid.,* 633. Though the calcns. of A. and M. may be desirable, better standardization would result from the adoption of a standard, and preferably long, light path.—*CA*

The Photometric Estimation of Color in Turbid Waters. A. G. KNIGHT. J. Inst. Wtr. Engrs. (Br.), **5**:623 ('51). With certain limitations color in a turbid water can be estd. photometrically without the disturbing facts of filtration or other clarifications by using the differential absorption of the water in this spectral region. The instrument must be calibrated at the pH value to be used. A natural color rather than the Pt-Co standard should be used. A calcg. rule was devised.—*CA*

The Analysis of Water by the Assessment of Turbidity. H. E. ROSE. J. Inst. Wtr. Engrs. (Br.), **5**:521 ('51). The study of the action of light will give certain data concerning the suspended material in water. A photo-extinction app. was devised which gives abs. results and calibration is not required. Addnl. observation of the photo-extinction method may allow the computation of size frequency, the mean size, and the concn. of the suspended material, even in cases where the concn. is so low that gravimetric analysis is impossible. There appears to be need for basic research.—*CA*

The Pneumatic Water Sampling Apparatus. RUDOLF H. LAUN. Gas- u. Wasserfach (Ger.), **92**:16:200 ('51). The disadvantages of previous apparatus for sampling water at various depths are pointed out, and a description is given of a new apparatus, in which air pressure from a rubber bulb is transmitted through rubber tubing to the sampling device at the desired depth, permitting sampling of the water in a sterilized ampul.—*CA*

HYDRAULICS

The Effect of Water-Air Surge Tanks on Water Hammer in Pressure Conduits. IGNACY PIOTROWSKI. Gaz, Woda i Techn. Sanit. (Pol.,) **24**:41

(*Continued on page 64*)

(*Continued from page 62*)

(Feb. '50). Several solns. presented for detg. pressures resulting from water hammer in pressure conduits and sizes of surge tank that may be required to minimize effect of these pressure fluctuations. In first 3 methods given below, water and pipe material considered inelastic and changes in vol. in air occur isothermally. Expressions derived formulated below: *Method I.* Increase in pressure indicated by:

$$p - p_0 = v_0 \sqrt{\frac{p_0 F_1 L\gamma}{V_0 g}} \cdot \sin\left(t\sqrt{\frac{p_0 F_1 g}{L\gamma V_0}}\right)$$

As curve of changes in pressure in surge tank is similar to sine curve, time in sec. for change in pressure may be represented by

$$T = 2\pi\sqrt{\frac{L\gamma V_0}{p_0 F_1 g}}$$

and max. and min. pressures, in kg/sq m, may be found from

$$p_{\text{min.}} = p_0 - v_0\sqrt{\frac{F_1 L\gamma p_0}{g V_0}}$$

$$\text{and } p_{\text{max.}} = p_0 + v_0\sqrt{\frac{F_1 L\gamma p_0}{g V_0}}$$

These formulas indicate that changes in pressure in surge tank increase with increase [1] in initial veloc. of water, [2] in capac. of pressure conduit, and [3] in initial pressure; and decrease with increase [4] in vol. of air in surge tank. Formula given not exact, but error decreases as initial vol. of air in surge tank increases. If allowable value for $p_{\text{max.}}$ is known, necessary vol. of air in surge tank may be computed. *Method II.* An expression derived for p:

$$\ln\frac{p}{p_0} + \frac{p}{p_0} - 1 = \frac{L\gamma F_1}{2g p_0 V_0} \cdot v_0^2$$

(*Continued on page 66*)

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This equation may be solved with aid of curve in which $\ln \frac{p}{p_0} + \frac{p_0}{p} - 1$ plotted along ordinate and $\frac{p_{max.}}{p_0}$ and $\frac{p_{min.}}{p_0}$ plotted along abscissa. For value of $\frac{p_0}{p} = 1$, curve passes through point $x = 1$, $y = 0$, which divides curve into 2 branches—right branch indicating $\frac{p_{max.}}{p_0}$ and left $\frac{p_{min.}}{p_0}$. As p_0 is known, $p_{max.}$ or $p_{min.}$ may readily be found after solving expression above and using curve. From this equation find that changes in pressure in surge tank increase with increase [1] in initial flow of water, and [2] with diam. of pressure conduit; and decrease with increase [3] in initial pressure and [4] in initial vol. of air in surge tank. Comparing methods I and II, note that condition [3] in two methods at variance, whereas other conditions in agreement. *Method III.* Three formulations derived:

$$\Delta y = \frac{F_1}{F_2} v \Delta t$$

$$\Delta v = \frac{g}{L} \Delta t \left(H \pm \Delta y + \frac{p_a - p_0}{\gamma} \pm h_r \pm h_v \right)$$

$$p = \frac{p_0 V_0}{V_0 + \Delta V}$$

If t assumed to be 2 sec., these equations may be solved, as h_r may be found through use of Manning or other suitable formula. *Method IV.* Pipe material and water assumed elastic, no surge tank near pump, and loss of head in water-air conduit not taken into consideration. Derived expression is:

$$p - p_0 = \pm \frac{v_0}{\sqrt{\frac{g}{\gamma}\left(\frac{1}{E_w} + \frac{D}{S} \cdot \frac{1}{E_r}\right)}}$$

Values of E given for water, steel, cast iron, concrete, wood, and lead.

Key to Symbols:

F_1 — area of pressure conduit in sq m.
F_2 — area of surge tank in sq m.
L — length of pressure conduit in m.
H — difference in elevation of water surfaces in surge tank and elevated tank at time $t = 0$ in m.
t — time in sec. in which change of flow and pressure occurs.
V — vol. of air in surge tank in cu m.
V_0 — initial vol. of air in surge tank at time $t = 0$ in cu m.
p — absolute pressure in surge tank in kg./sq m.
p_0 — absolute pressure, initial at time $t = 0$ in kg./sq m.
p_a — atmospheric pressure in kg./sq m.
γ — specific gravity in 1000 kg./cu m.
g — force of gravity = 9.81 m./sec^2.
y — change in elevation of level of water in surge tank in m.
v — flow veloc. of avg. mass of water in m./sec.
v_0 — initial veloc. of water at time $t = 0$ in m./sec.
h_v — loss in head in passing from surge tank to pressure conduit in m.
h_r — loss in head in pressure conduit in m.
D — diam. of pressure conduit in m.
S — wall thickness of pressure conduit in m.
E_r — modulus of elasticity of pipe material in kg./sq m.
E_w — modulus of elasticity of water in kg./sq m.—*C. P. Straub.*

Emptying Time of Reservoirs. Rudolph Luss. Wtr. & Wtr. Eng. (Br.), **54**:8 (July '50). Formulas are given for time in which reservoir of given shape will empty. Exact solution is possible for strictly geometrical reservoirs.—*H. E. Babbitt*

Pressure Drop Through Fixed and Fluidized Beds—A Nomogram. M. Weintraub and M. Leva. Chem. Eng., **57**:110 ('50). A nomogram is given for determination of fall in pressure of fluids flowing through beds of granular materials such as sand filters. The nomogram is also applicable to cases in which the upward rate of flow of liquid is sufficient to render the whole bed fluid.—*WPA*

Water Measurements by Chemical Methods. G. Winkler & M. H. Wipe. Schweiz. Bauzt. (Swiss), **65**: 417 ('47). The authors have found $NaNO_2$ more satisfactory than NaCl as an indicator in chemical methods for detg. flow of water. An example of its use is described.—*WPA*

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(Continued from page 66)

STREAM POLLUTION CONTROL

How the Petroleum Industry Controls Pollution Caused by Oil Wastes. A. D. McRae. Munic. Utils., **89**:9:56 (Sept. '51). Visible sheen produced by 40 gal of oil on 1 sq mile of water, film thickness 0.000003". Most economical disposal of oil-field brines is injection into deep wells penetrating permeable strata. Brine passed through skimming unit to remove last traces of oil, aerated to oxidize Fe and partially stabilize carbonates, coagulated and settled, and finally filtered through open or pressure filters before gravity or pressure discharge to wells. Cl usually applied at some point in system to oxidize sulfides and destroy sulfate-reducing bacteria. H_2S produced by latter cause black FeS ppts. and, by oxidation, milky S ppts. In closed systems, hexametaphosphate used for stabilization. Cl can be produced at site by electrolysis of brine but corrosiveness of brine is problem. Glass- or porcelain-lined pumps and plastic pipe coatings employed. Of latter, phenolic thermosetting resin most successful. Back-flushing of wells necessary at times. Exclusion of bact. growths essential. In Great Lakes area, water ballast, normally 20–30% of tanker capac., must be pumped ashore. Emulsions broken by heat and chem. treatment, and oil recovered. No oil nor oil-contg. water discharged overboard within 100 miles of land, except in emergency. Within this limit, vessels may discharge ballast to approx. pipeline level, making sure that oil does not escape. All bilge valves closed while in port and pumproom sea valves closed and sealed during loading and unloading. Refinery requires avg. of 64,000 gal cooling and service water/100 bbl. of crude oil processed. Recirculation through cooling towers reduces this amt. to one tenth. Standard type Am. Petroleum Inst. separator produces effluent with 30 ppm oil, max., if influent reasonably free from sediment and oil-in-water emulsions. Careful segregation of oil-contg. wastes reduces vol. to be treated. NaOH regenerated by steaming out mercaptans and burning them. When no longer of use, neutralized with flue gas contg. SO_2 and CO_2. Phenols excluded from waste water by closed surface condensers for petroleum vapors and by efficient recovery methods where phenol used as selective solvent. Biol. destruction of low concns. of phenols less expensive than oxidation with Cl, ClO_2, or O_3. Ideal sequence: [1] modification of process to reduce phenol, [2] biol. oxidation to low phenol conc., [3] chem. cleanup of effluent from [2] when required. Rotary pre-coat filters and centrifuges successful for some emulsions.—*R. E. Thompson.*

Rapid Growth of Saskatoon Has Increased Water and Sewage Problems. D. G. Hoskin. Munic. Utils., **89**:11:19 (Nov. '51). Pop. served nearly 60,000, exclusive of adjacent areas supplied. Source of supply South Saskatchewan R. Sewage, without treatment, discharged into river after comminution. Intake pier dislodged by ice last spring, leaving intake pipe lying on river bed. Estd. 1,500 cu yd sand removed from suction well and 7,000–8,000 cu yd from sedimentation basins. Turbidity 10–4,000 ppm, at times colloidal. Only mixing that resulting from turbulence in piping and as water enters two 1.5-mil gal baffled sedimentation basins operated in series. Mechanically-equipped solids-contact basins planned. Filter plant, 12 mgd rated capac., consists of 3 groups of 6 units each, constr. in '12, '28 and '49, resp. Reconstr. of first group almost complete. Second group

(Continued on page 70)

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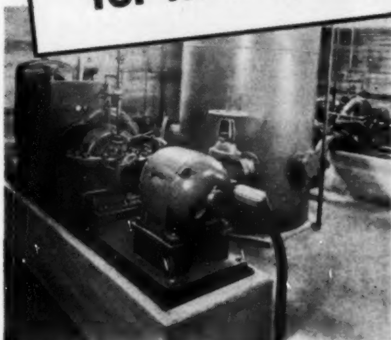

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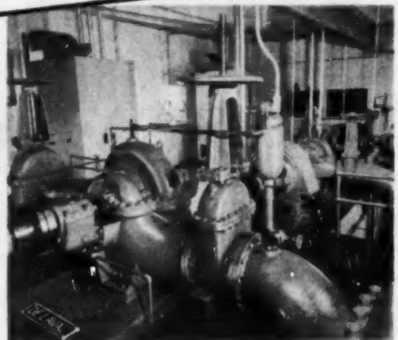

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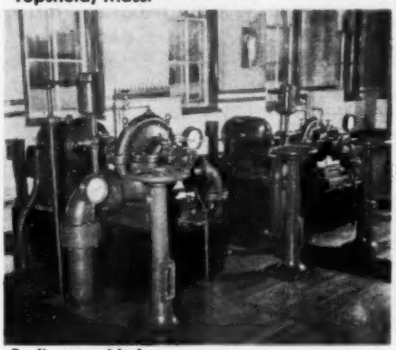

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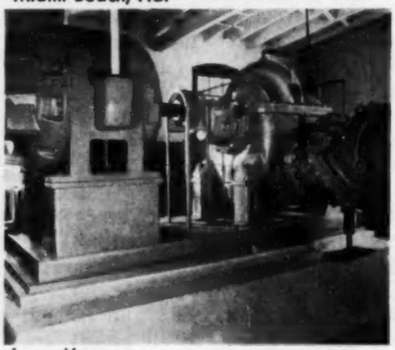

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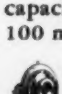

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(Continued from page 68)

also to be rebuilt. Sand and gravel processed locally. Sand effective size 0.50 mm., uniformity coefficient 1.65. Air-water wash effective in preventing mud balls. Rise during wash 19"/min. Normal postchlorination dosage, 0.8 ppm. Residual after 15 min. contact available before water pumped to city, 0.3 ppm., of which 0.2–0.25 free Cl. During winter, when water pumped direct to filters, prechlorination dosage, 0.5 ppm. High- and low-lift pumps and controls being entirely replaced. New units will operate at 40- and 185'-heads, resp. Discharge pressure into mains 74 psi. Ground-level reservoir, 4 mil gal capac., under constr. near plant. Only other storage two 160,000-gal standpipes on small pipelines. Partial softening, to reduce hardness from 250–340 ppm to 100 proposed. Water unaccounted for, 30%; expanded meter-test and leakage-survey program planned. Water safe and palatable. Bact. anals. made at Univ. of Saskatchewan.—*R. E. Thompson.*

The Development of Water Supply and Sewage Treatment in the Six-Year Plan. Józef Liebfeld. Gaz, Woda i Techn. Sanit. (Pol.), **25**:193 (July, Aug. '51). In Poland, 369 cities (52.3% of all cities) are provided with water works and 336 cities do not have water supplies. In these cities, water is taken from shallow wells or from untreated surface streams. Water supply systems serve 494 of total of 3,000 rural villages and about 40,000 settlements or approx. 1.2% of the total. After World War II there was an increase of 103 and 765%, resp., in the number of cities and the number of settlements served by water supplies. In addition avg. per capita consumption of water increased by 42%—from 55 to 78 l./capita/day. Much of the increase is due to fact that many water supplies existed in cities annexed to Poland in western territories as compared with number of water supplies in remaining portions of country. For the 3-year plan '47–'49, and including the funds for '45–'46, about 5 billion zloty were authorized for water supply and sewerage systems. Six-year plan, '50–'55, forsees rehabilitation of all presently inoperable water and sewerage systems, installation of water supply systems where these are lacking, and constr. of 40 water works and 30 sewerage systems in cities not possessing either. In addition, it is planned to extend water distr. and sewerage systems and to increase quantity of water available to industry and to pop.—*C. P. Straub.*

Radioactive Waste Disposal. John F. Newell & C. W. Christenson. Sew. & Ind. Wastes, **23**:861 ('51). Radioactive material discharged to streams, rivers, and lakes will tend to concentrate in aquatic life which apparently is not harmed by the radioactivity normally present in wastes. Natural ground and surface waters have been found to contain some Ra. Certain springs contain relatively high concn. Radioactive material can be handled (a) by storage which is particularly effective for short-life isotopes; (b) evapn.; (c) ion exchange; (d) chem. coagulation with Fe lime, and phosphate; (e) adsorption on pumice celite, tufa, and C; (f) biol. methods in limited applications.—*CA*

GENERAL TREATMENT

New Aeration System for Raw Water. P. C. Lindenbergh. Water (Neth.), **36**: (Jan. 3, '52). Since 1913 the Leiden water has been aerated with Amsterdam aerators mounted above the filters. Troubles developed as a result of incomplete oxidation of iron and subsequent cementing of sand grains, and shorter filter runs.

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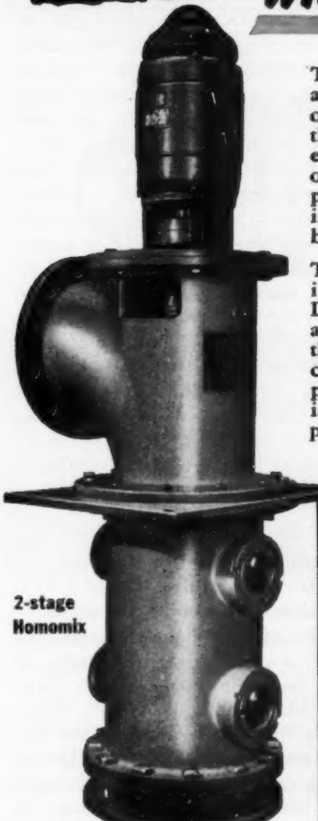

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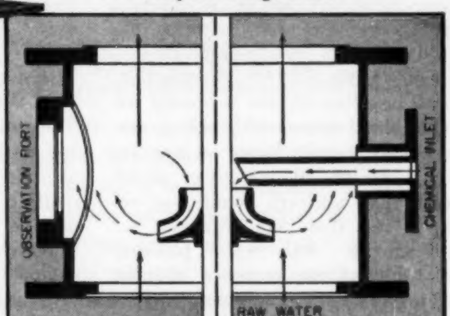

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(*Continued from page 70*)

The new system consists of three concentric tubes; the outer tube is 4 m high and 1 m in diam. Water and air are introduced at the bottom of the inner tube. The mixture rises through the inner tube, flows down through the middle ring, and rises again through the outer tube for discharge to the filters. Air is introduced tangentially, causing turbulence and mixing. Water travels 3 to 4 times the length of the tube resulting in detention time of several minutes. System is claimed to be economical, effective, to reduce constr. costs, and be adaptable for introduction of chems.—*W. Rudolfs.*

Simple Apparatus for Chlorinating Water Supplies. ALFRED SOBOTA. Gaz, Woda i Techn. Sanit. (Pol.), **25**:37 (Feb. '51). A simple installation for continuous chlorination of water, which has been in use for over 1 yr in a water plant in Silesia, is described. NaOCl is used as disinfecting agent. Installation includes several constant head tanks connected through an injector (similar to a lab. suction pump) to distr. system or storage tank. A batch of chlorine water is prepared and injected into distr. system at rate comparable to flow and sufficient for disinfection. Similar installations are proposed for use with small household-pressure systems. Some results based on samples collected in '49–'50 are given which indicate that coliform count was reduced to less than one organism per 50 ml sample. Raw water coliform counts showed the presence of coliform organisms in samples smaller than 10 ml. Other bact. data are included which show reduction in counts on gelatin (20 C, 48 hr) and agar (37 C, 24 hr) following addition of sufficient chlorine to maintain a free chlorine residual of 0.1–0.3 mg/l. —*C. P. Straub.*

Deliquescence and Solution Rate Control of Glassy Phosphate Powders. CASIMIR J. MUNTER. U.S. Patent 2,566,424 (Sept. 4, '51). Phosphate glasses deliquesce in air, and in water resist soln. by particles cohering into a sticky mass. By coating surface of these particles with either an acid or an acid salt, such as citric acid or NaH_2PO_4, and mixing with a gas-releasing substance, such as $NaHCO_3$ and Na_2CO_3, the evolved gas on placing in water disperses the particles, permitting much faster rate of soln. The gas-releasing compd. may be caused to adhere to the particles instead, and the acid mixed in as a powder, or parts of the phosphate glass may be treated contrariwise. Adherence of the powders to the phosphate glass is improved by mixing in a current of humid, warm air, followed by drying. Bulk is increased and the powder-covered product made free-flowing. At least ½% of an acid or 2% of an acid salt, and 2½% each of $NaHCO_3$ and Na_2CO_3 are typical compns., based on wt. of phosphate glass. For boiler waters $NaHSO_3$ or Na_2SO_3 may be substituted in order to release SO_2 as the dispersing gas.—*CA*

Microstraining. P. L. BOUCHER. J. Inst. Wtr. Engrs. (Br.), **5**:561 ('51). The process involves the use as filtering media of very fine woven fabrics of stainless steel which are capable of matting on their surfaces thin layer of sand which, with the fabrics, has a relatively high flow rating at low hydraulic resistance and is capable of retaining suspended solids of sizes smaller than the minute openings of the fabric. The fabric is mounted on a revolving drum immersed in the liquid to be filtered with jets at the top for wash. The process is used as a prefilter for slow sand filters and can be compared with roughing filters.

(*Continued on page 74*)

(Continued from page 72)

There are some operational difficulties, but tests of installations at several filter plants would seem to indicate that it would be practical in reducing the time between cleaning of slow sand filters.—*CA*

WELLS & GROUND WATER

Water Supply From Horizontal Borings. IGNACY PIOTROWSKI. Gaz. Woda i Techn. Sanit. (Pol.), **25**:65 (Mar. '51). Various formulations developed by Dupuit and others for detg. flow rate into vertical wells under conditions of normal and artesian flow, and flow into horizontal drain or well, are given. An attempt is made to develop a method for detg. yield from horizontal wells to be drilled under the Vistula R. for augmenting Warsaw water supply. As first approximation, assumed that flow through soil under Vistula R. to underdrains (horizontal wells) would be analagous to flow through slow sand filter with exception that, in latter, boundaries are defined. Loss of head is computed and an est. of yield is made. Ranney method of driving horizontal wells is reviewed and compared with Swiss method developed by Fehlmann. Advantages claimed for Fehlmann method are: [1] instead of driving heavy-walled perforated pipe for collecting water, horizontal drilling used, thus permitting use of thinner-walled pipes and re-use of costly, heavier drill pipes; [2] on basis of material washed out in drilling, can det. specifically geological formations traversed by wells; [3] if lenses of fine soil or clay are met, screened filters or solid pipes may be used; [4] openings in screen may be adjusted to size of material in water-bearing strata; [5] danger of clogging filter well screens is eliminated; and [6] to obtain longer lengths telescopic boring or drilling may be employed. A table is presented in which various characteristics are compared in the Ranney and Fehlmann installations.—*C. P. Straub.*

Principle of the Estimation of Subterranean Waters. I. I. CHEBOTAREV. Wtr. and Wtr. Eng. (Br.), **55**:129 (April '51). Theory of frequency and mathematical statistics is considered to be only possible method for correct and objective estn. of distr. of subterranean waters. Data concerning underground water estimation: [1] depth to aquifer, thickness of aquifers, rise in pressure of water, supply and temperature, and [2] coefficient of permeability of water-bearing strata, velocity of underground water movement, yield possibilities, physical properties of sediments in relation to water, and chemical composition of water. Arranging data in either increasing or decreasing order we can compile table of distr. of statistical aggregates. If arranged to show number of times, or frequency, with which event happens in particular way, then arrangement is frequency distr. Distr. curve shows which magnitudes of variant of given distr. are most often repeated. Distr. curves have two typical forms, symmetrical and unsymmetrical. Latter is termed "skew curve." Skewness $= \frac{x_a - x_m}{\sigma}$, where x_a is mean of all units in given distribution, x_m is mode or position of max. ordinate and $\sigma = \sqrt{\frac{\Sigma(x^2_n)}{n}}$ where x_n is deviation from mean, and n is total number of items. Chief characteristics of subterranean water, such as depth, thickness of aquifer, and hardness, cannot have magnitude less than zero, and upper limit of data cannot be determined. Equation of this curve is

$$y = y_0\left(1 + \frac{x}{a}\right)^{\gamma a} \cdot e^{-\gamma x}$$

(Continued on page 76)

(*Continued from page 74*)

where y is ordinate of frequency, x is deviation from mode, e is base of Naperian log, y_0, γ, and a are constants with following expressions: $y_0 = \dfrac{N \cdot p^{p+1}}{a \cdot e^p \tau(p+1)}$ where N is total area under frequency curve $= 100\%$ (or total number of variants in distribution), and $\tau(p+1)$ is gamma function of $(p+1)$; $\tau(p+1) = p \cdot \tau(p)$. For purpose of estn. of subterranean water possible to take into account only most characteristic frequency—1, 25, 50, 75, and 99%. Using data presented for ordinates of integral curve, can plot desired curve of distr. under consideration. On axis of ordinates computed, value of k ($k = \dfrac{x}{x_a}$ in which x is variant of statistical distr.) is plotted in terms of mean, and on axis of abscissas, percentage of frequency. Fundamental advantage of integral frequency curve lies in possibility of finding any desired characteristics of subterranean waters with math. accuracy. Frequency of occurrence is only useful principle for analyzing observed hydro-geological phenomena. Frequency of 50% has been taken as typical characteristic for subterranean water distr. When there is adequate observed distr., forecast of given phenomenon is not difficult and integral curve solves it quickly and accurately.—*H. E. Babbitt.*

Report of the Uniform Plumbing Code Commission. U.S. Dept. of Commerce & Home Finance Agency, Washington, D.C. ('49). Committee

(*Continued on page 78*)

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has extended its investigations to include plumbing for commercial and industrial installations as well as for housing. In this report, stds. are set forth for materials to be used for plumbing and design of plumbing fixtures and piping for water supply, disposal of harmful wastes, sewerage systems, and storm drainage. In appendixes, which are not part of code, recommendations made for design of individual water-supply and sewage-disposal systems.—*W.P.A.*

SOURCES OF SUPPLY

The Water Resources of Calvert County. V. R. BENNION, D. F. DOUGHERTY, & R. M. OVERBECK. Maryland Dept. Geol., Mines, and Water Resources Bul., **8**:1 ('51). This includes analyses of 11 waters. —*CA*

Ground-Water Resources of the Lower Yellowstone River Valley between Miles City and Glendive, Montana. A. E. TORREY, F. A. SWENSON, & H. A. SWENSON. U.S. Geol. Survey Circ., **93**:1 ('51). Analyses of 25 waters are given. Some are very soft waters from deep artesian wells and are high in $NaHCO_3$. —*CA*

Ground-water Conditions in the Dutch Flats Area, Scotts Bluff and Sioux Counties, Nebraska. H. M. BABCOCK, F. N. VISHER, & W. H. DURUM. U.S. Geol. Survey Circ., **126**:1 ('51). This includes 10 analyses of moderately hard $CaHCO_3$ bicarbonate waters.—*CA*

Chemical Quality of the Surface Waters in the Loup River Basin, Nebraska. J. G. CONNOR. U.S. Geol. Survey Circ., **107**:1 ('51). Many analyses are given. The waters are moderately hard $CaHCO_3$ waters contg. 35–58 ppm SiO_2.—*CA*

Hydrology of Eastern Nevada. Ground Water in Goshute-Antelope Valley, Elko County, Nevada. T. G. EAKIN, G. B. MAXEY, & T. W. ROBINSON. Nevada Office State Engr., Water Resources Bul., **12**:21 ('51). Analyses are given of 4 waters, 2 of which are high in sulfate, Cl, and F. —*CA*

Ground Water in the Vicinity of Elko, Nevada. J. C. FREDERICKS & O. J. LOELTZ. *Ibid.*, 35. This includes analyses of 5 waters, all moderately mineralized.—*CA*

Ground Water in Ruby Valley, Elko and White Pine Counties, Nevada. T. E. EAKIN & G. B. MAXEY. *Ibid.*, 65. Analyses of 4 waters are given. Two are high in alkali bicarbonate and 1 contains 8 ppm F.—*CA*

Ground Water in Clover and Independence Valleys, Elko County, Nevada. *Ibid.*, 95. Analyses of 5 waters are included.—*CA*

Ground Water in Railroad, Hot Creek, Reveille, Kaurch, and Penoyer Valleys, Nye, Lincoln, and White Pine Counties, Nevada. G. B. MAXEY & T. E. EAKIN. *Ibid.*, 127. Analyses of 3 waters are given.—*CA*

Geology and Ground-Water Resources of San Miguel County, New Mexico. R. L. GRIGGS & G. E. HENDRICKSON. N. Mex. Bur. Mines & Mineral Resources, Ground-water Rept., **2**:1 ('51). Analyses of 81 waters are included.—*CA*

The Ground-Water Resources of Columbia County, New York.

(*Continued on page 80*)

(Continued from page 78)

THEODORE ARNOW. N.Y. Dept. Conservation, Water Power, & Control Com., Bul., **GW-25**:1 ('51). This includes analyses of 24 waters, mostly soft to moderately hard.—*CA*

The Ground-Water Resources of Fulton County, New York. THEODORE ARNOW. N.Y. Dept. Conservation, Water Power, & Control Com., Bull., **GW-24**:1 ('51). Analyses of 30 waters are given.—*CA*

The Ground-Water Resources of Schoharie County, New York. J. M. BERDAN. N.Y. Dept. Conservation, Water Power, & Control Com., Bull., **GW-22**:1 ('50). This includes 31 analyses, mostly of moderately hard bicarbonate waters.—*CA*

The Ground-Water Resources of Seneca County, New York. A. J. MOZOLA. N.Y. Dept. Conservation, Water Power, & Control Com., Bul., **GW-26**:1 ('51). This includes analyses of 41 samples. Most are hard waters and many have high sulfate contents.—*CA*

Chemical Character of Surface Waters of Ohio, 1946–1950. W. L. LAMAR & M. E. SCHROEDER. Ohio Dept. Natural Resources, Div. Water Bul., **23**:1 ('51). Many analyses are given.—*CA*

Chemical Composition of Texas Surface Waters, 1949. BURDGE IRELAN, *et al.* Texas Board of Water Engrs., Oct. '50. Several hundred analyses of waters are given.—*C.A.*

INDUSTRIAL WATER SUPPLY

Chromium Salts in the Treatment of Cooling Water. OTTO HAHN. Erdöl u. Kohle, **4**:565 ('51). Addn. of K_2CrO_4 or Na_2CrO_4 (0.05%) will prevent the growth of bacteria and slime in cooling water.—*CA*

New Developments in Water Conditioning for Diesel Locomotive Cooling Systems. M. A. HANSOM. Am. Ry. Eng. Assoc. Bul., **53**:497:253 ('51). Alk. chromate inhibitors with concn. of Na_2CrO_4 maintained at least 1.5 lb. per 100 gal. have given good results. Of various substitutes for chromate a treatment with a mixt. of 95% borax and 5% $NaNO_2$ at a concn. of 3–4 lb/100 gal appeared to give good inhibition.—*CA*

Public Supplies for Butter Wash Water. H. RADEMA. Water (Neth.), **35**:223 (Sept. '51). Question of which water supply to use for butter washing is an old one in Friesland in connection with taste and odor of butter. Inspections for 10 yr show that, of 398 factories using water from public supplies, 292 obtained common and 63 special certificates (90.2%). The 333 factories that treat their own water received 115 common and 15 special certificates (39%) for absence of undesirable taste and odor.—*W. Rudolfs.*

Industrial Water Supply Problems in Poland. EMIL WINTER. Gaz, Woda i Techn. Sanit. (Pol.), **25**:4:116 (April '51). Water supplies should be so installed as to guarantee a continuous supply of water in an emergency, and each larger industry should have access to two separate sources of supply, each delivered to the plant through its own pipeline or distr. system. Provisions should also be made for storage of water. Basically, industrial water may be classified according to use: [1] water for drinking and ablutionary purposes, [2] water re-

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quired for production with quality dependent upon end use (food establishments—potable water, paper and textile mills—iron-free water, soft water, etc.), [3] water for steam production, [4] water for washing coal, for cooling in steel mills, for flotation, and [5] water for cooling closed systems and other modern industrial equip. Sample calcn. of the cost of softening certain mine waters for steam generation indicate that cost varies from 8 to 28 zloty/cu m before present currency devaluation or approx. $30 to $106/mil gal depending upon initial hardness. Chem. treatment is considered for softening. Amt. of water used annually by industry at present is 1.3×10^9 cu m and will increase shortly to 3×10^9 cu m. Much could be saved annually if soft water were available for all industries. Consideration should be given to disposal of industrial wastes. Suggest that each specific industry be studied to det. best method of waste disposal and treatment. Biggest lack is in qualified and trained personnel for study of these problems.—*C. P. Straub.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals, are listed below.

High-Frequency Titrations. W. J. Blaedel & H. V. Malmstadt. Anal. Chem., **22**: 1410 ('50).

Hydrogen-Utilizing, Sulphate-Reducing Bacteria in Marine Sediments. F. D. Sisler & C. E. ZoBell. J. Bact., **60**: 747 ('50).

Seagoing Photoelectric Colorimeter. W. L. Ford. Anal. Chem., **22**: 1431 ('50).

(Continued from page 14)

Eau Claire *eau* isn't so *claire* any more and Eau Claireans are suing each other about it. Fortunately it isn't the *eau potable,* but the *eau de natation,* that is causing the trouble, and swimming suits concern us less these days than once they did. We should explain, however, that it was pollution of Half Moon Lake, located within city limits, which caused 1,764 qualified elector-swimmers to start something. They petitioned the city council to install catch basins in storm sewers that emptied into the lake and to rebuild a long-abandoned log flume to bring "fresh" water from the Chippewa River, a mile away, to the lake. Council chose to submit the project to the voters in a referendum scheduled for All Fools Day. Then the city brought suit against what amounts to more than 10 per cent of its voters to forestall the vote on the grounds that the project would be "futile and a waste of time and money."

Eau not so *Claire* and *Claire de* only half a *Lune*—and it all happened in Wisconsin.

A new pH meter has been introduced by the Research & Control Instruments Div., North American Philips Co., Inc., 750 S. Fulton Ave., Mt. Vernon, N.Y. The device offers currentless measuring with a range of 0–14.5. It utilizes a cadmium standard cell and cathode ray zero indication.

Gilbert H. Dunstan has been appointed professor of sanitary engineering in charge of work in that department at the State College of Washington, Pullman, Wash. Previous experiences have been with the Public Health Service and the engineering faculties of the University of Iowa, Tulane University, University of Southern California, and University of Alabama.

Proportioning weir tanks for dividing the flow of solutions or suspensions into variable proportions have been developed by Omega Machine Co., Providence, R.I. The tanks include a stilling chamber, a rectangular weir, and a flow splitter graduated to read percentages of total flow. The flow splitter may be pneumatically or electrically controlled for use in proportioning or automatic pH control systems.

A new type of orifice meter developed by the Fischer & Porter Co. measures a continuous bypass stream around the orifice, instead of measuring the static-pressure differential across it, as is done with mercury manometers. Known as the V/A Cell, the unit is said to offer greater chart accuracy at low flow, with consequent more exact ratio control, and simple, pneumatic central control.

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MUELLER
WATERWORKS EQUIPMENT
Standard of Perfection
TAPPING & DRILLING MACHINES
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GATE VALVES
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MUELLER CO. offers you a complete selection of waterworks distribution equipment, supplies and specialties designed and manufactured to high standards of quality and perfection. *Write for catalog information on any of these product lines.
See Our Booths 85 and 86 at the AWWA Convention in Kansas City
MUELLER CO.
Dependable Since 1857
MAIN OFFICE & FACTORY DECATUR, ILLINOIS

(Continued from page 84)

Clinton F. Robinson has been elected president and director of the Carborundum Co., succeeding H. K. Clark, who has resigned but will retain his seat on the board.

Warren J. Newman, district engineer in northeastern Pennsylvania for Wallace & Tiernan Co., Inc., has been recalled to duty by the Navy. During his expected year and a half to two years of active duty, he will be on military leave of absence.

Charles F. Hauck has been appointed manager of sales promotion of the Chemical Plants Div., Blaw-Knox Co. A veteran of 15 years' work in chemical engineering and water processing, he will work on the development of new markets and direct advertising and information activities.

W. B. Harman, acting manager of the Newport News Water Works Commission, has been appointed general manager of the system, succeeding the late Eugene F. Dugger. James M. Pharr has been appointed assistant general manger. Harman has been with the utility since 1920 and became its assistant general manager in 1937.

(Continued on page 88)

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Inflation has hit fire fighting too, estimated fire losses for 1951 reaching an all-time high of $731,405,000 compared with the previous high of $711,114,000 set in 1948. How much of the difference is inflationary and how much inflammatory is difficult to judge, but regardless of the extravagance of our price spirals we ought to do better than an increase of 132 per cent in ten years. That represents a lot of water that could very well be saved.

Mark L. Stuppy has joined the F. B. Leopold Co., Inc., of Pittsburgh, and is representing the firm in the building of water and sewage treatment plants. He had formerly been associated with Simplex Valve & Meter Co.

Joseph F. O'Grady has been appointed sales manager of the Water Meter Div., Rockwell Mfg. Co. For the last five years supervisor of sales in the Pittsburgh district, he has been with the organization since 1940.

Irving B. Remsen Jr. has joined Hall Labs., Inc., as a technical consultant on waste water problems.

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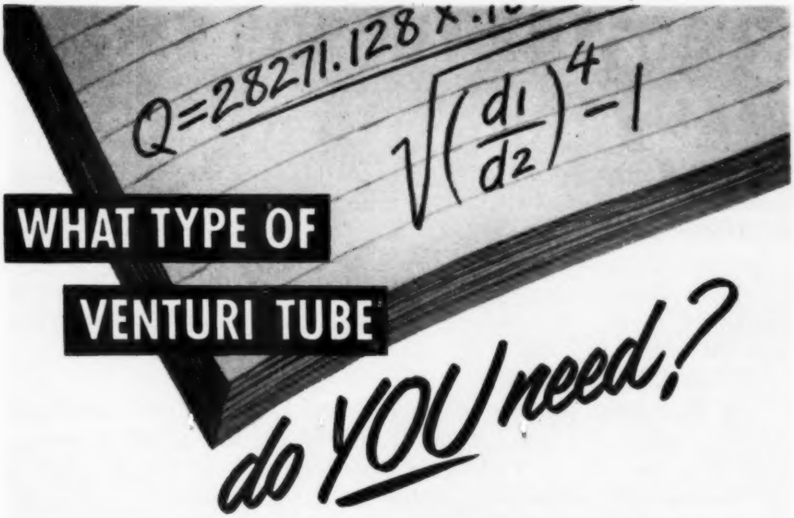
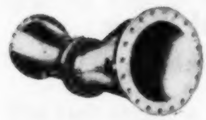


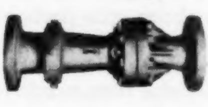
WHAT TYPE OF VENTURI TUBE do YOU need?

1. Steel plate tube with cast iron throat section for measurement of clear water, air or gases.

2. Cast iron Venturi Tube with hand holes and cleaning valves at main and throat sections, for municipal sewage and trade wastes.



3. Cast iron Venturi Tube with flat invert and single cleaning valve at main and throat sections. Specifically used for sludge.



4. Cast steel or cast iron Venturi for hot or cold water and adaptable for boiler feed high pressure service.

IT'S SIMPLEX
IT'S ACCURATE

SIMPLEX makes Venturi Tubes for measuring cold water, raw sewage, trade waste, sludge, process liquor, boiler feed, air and gases.

These tubes come in many sizes and different designs, some of which are pictured above. This means there's a particular tube to fit specific needs.

Write, stating your Venturi Tube requirements, to Simplex Valve & Meter Company, Dept. 4, 6784 Upland Street, Philadelphia 42, Pennsylvania.

SIMPLEX

VALVE AND METER COMPANY

(Continued from page 88)

Luther W. Armstrong has been appointed service engineer for Builders-Providence, Inc., and Omega Machine Co. in the territory embracing Oregon, Washington, British Columbia and Alberta.

L. E. Harper, president of Omega Machine Co., has moved his headquarters from Wilmette, Ill., to the Builders Iron Foundry main office at 345 Harris Ave., Providence, R.I.

C. K. Hood has been elected vice president of Worthington Pump & Machinery Corp. Previously he had been manager of the New York sales office.

H. E. Hilton, formerly executive director of the National Automatic Sprinkler and Fire Control Assn., has joined the staff of the American Standards Assn. as its Washington representative. He will be working with the National Bureau of Standards and other government agencies on various standardization projects, as well as with trade and technical groups in Washington.

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(*Continued from page 90*)

The fountain of youth has apparently been discovered at long last, and, quite properly, by an AWWA member—W. H. Weaver, general manager of the DeKalb County Water System at Decatur, Ga. Characteristically modest and public spirited, Weaver has piped the stuff to his customers without upping his rates, or even telling them about it. And it wasn't until flower fancier Mrs. Fletcher Pearson Crown found that it wasn't necessary to disembowl the camellia she had submerged in one of those upside-down goldfish bowls more than five years ago that the discovery was discovered. Then, displaying a cream-colored *Angela coche* to newspapermen, Mrs. Crown explained that the bloom, which is still perfect, was light pink and its leaves a slightly darker green when it was put into the bowl of tap water in December 1946. Not only does the camellia remain virtually unchanged, but the water is still perfectly clear too, unchanged though unchanged in all this time.

It is still rather early to determine, even upon the basis of empirical evidence, how efficacious this essence of adolescence will be in liquidating human senescence, but we're beginning to feel bullish about Decatur real estate. The investigation itself, we have had to entrust to Georgia State Public Health Engr. N. M. DeJarnette, who, on the basis of a personal aversion to positive lactose broth tubes, is independently also looking into the possibilities of substituting a camellia test.

Service Lines

Nonclogging spray nozzles which permit washing by the use of plain pipe into which holes are drilled at desired spray locations are described in Folder 2386 of Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill. The nozzles are simply curved bronze deflectors that are positioned and attached to the pipe by means of a U bolt and nuts. The deflector directs the fan-shaped washing spray. Tables are included relating the diameter of orifices and water pressure to volume of spray.

Speed reducers, gears and other products of Philadelphia Gear Works, including the LimiTorque Valve Control, are featured in a folder, Catalog L-50, offered by the company, which is located at Erie Ave. & G St., Philadelphia 34, Pa.

Automatic regulating valves are shown in a folder, Bul. 700, issued by Spence Engineering Co., Inc., Walden, N.Y., to describe its pilot-operated pressure or temperature regulators and pump governors.

The stock flow-meter program that Fischer & Porter Co., 5580 County Line Rd., Hatboro, Pa., have based on "predictable" metering floats for their Flowrator "area" flow meter is described in a folder that is available on request.

The 1952 Difco catalog features dehydrated culture media and laboratory reagents. The 28-page price list may be procured from Difco Labs., Inc., Detroit 1, Mich.

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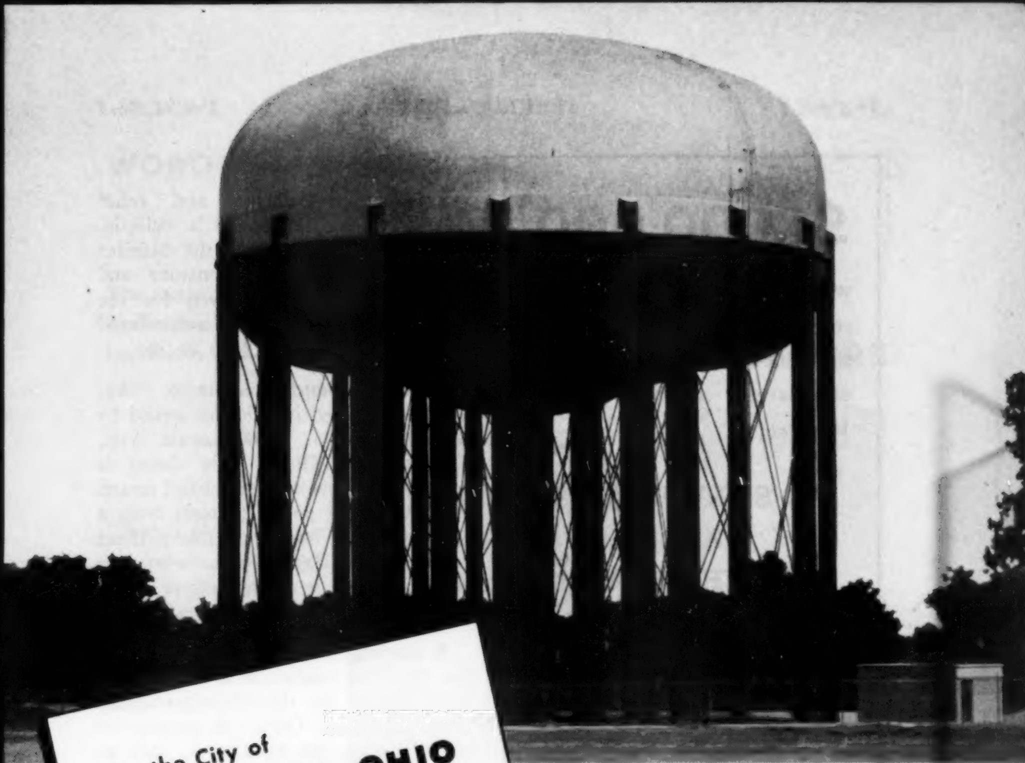

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Pressure regulators and relief valves are the subject of a bulletin, No. 8746, available from the Mueller Co., Decatur, Ill. Dimensions and working features are given for the regulating devices, which are offered in a size range from ½ to 2½ in.

A quarter-bend cable clamp, "Sky-Tie," is depicted in a leaflet issued by Adalet Mfg. Co., 14300 Lorain Ave., Cleveland 11, Ohio. The clamp is designed to serve as a simplified means of transmitting power to tools from a bus duct using bus-drop cable without conduit. The clamp acts as a support and an auxiliary spring acts to maintain tight cable runs.

A coating for concrete pipe, Rexon No. 2, is the subject of a folder, Bul. R-2, offered by the Hamilton Kent Mfg. Co., Kent, Ohio. A mixture of liquid resins, the coating is said to penetrate upon application and then vulcanize, forming a polished, rubber-like surface that is chemically resistant to acids and alkalies and impervious to water.

Services offered by Pittsburgh Pipe Cleaner Co. are described in a folder offered by the company, which is located at 4920 Leonard St., Pittsburgh 13, Pa.

An alkalinity-reducing ion exchanger, designed for treating boiler feed of high alkalinity and moderate chloride and sulfate content, is described in a leaflet, 28 × 7808, being distributed by Allis-Chalmers Mfg. Co., 1026 S. 70th St., Milwaukee, Wis.

Hydrofluosilicic acid for fluoridation of municipal water supplies is being offered by E. I. du Pont de Nemours & Co., Fine Chemicals Div., Organic Chemicals Dept., Wilmington 98, Del., in a 30 per cent aqueous solution. A folder describing the product is available.

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(*Continued from page 96*)

Copper and lead analysis by electroanalysis is the subject of a 20-page pamphlet offered by Eberbach Corp., Ann Arbor, Mich.

"Proper Valve Lubrication," a reprint of a paper by E. W. Horvick, is being distributed by Minneapolis-Honeywell Regulator Co., Station 40, Wayne & Windrim Aves., Philadelphia 44, Pa.

Burrell's "Announcer of Scientific Equipment," a bimonthly publication about laboratory equipment and supplies, may be obtained on request to Burrell Corp., 2223 Fifth Ave., Pittsburgh 19, Pa.

The Hydrocrane—a hydraulic crane manufactured by Bucyrus-Erie Co., South Milwaukee, Wis., is described in a 24-page brochure that also illustrates some of the many applications of the tool—trenching, placing pipe, backfilling, erecting and unloading.

Monobed ion exchange is the subject of a catalog sheet just issued by Penfield Mfg. Co., Inc., 19 High School Ave., Meriden, Conn. The demineralizer unit is available in sizes yielding flow rates from 10 to 10,000 gph.

Fractional horsepower motors in open, dripproof and totally enclosed, fan-cooled models are featured in a 16-page, lavishly illustrated brochure, GEA-5567, being distributed by the General Electric Co., Schenectady 5, N.Y.

Automatic water and steam valves manufactured by Golden-Anderson Valve Specialty Co. are featured in an 8-page booklet, Bul. G-3, that may be obtained from the company, 2091 Keenan Bldg., Pittsburgh 22, Pa. Float, altitude, check, reducing, and other "cushioned" valves are described and illustrated.

(*Continued on page 100*)

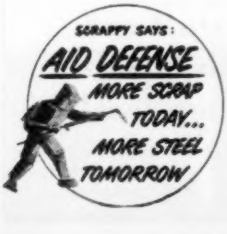
You Lose When Scrap Plays Hide-and-Seek

It doesn't look as though there is much scrap in this storage yard, does it? But look closer. Tons of iron and steel scrap are hidden here.

Could this be true of your storage yard?

If so, you should gather up all such worn-out iron and steel equipment, then call your scrap dealer immediately. Scrap is desperately needed to keep the nation's steel mills going. Unless everyone pitches in, steel production may have to be curtailed in the months to come. Both the defense program and civilian production would suffer.

Here's what you can do to help. Survey storage yards, treatment plants and pumping stations for all kinds of scrap metal. Collect all worn-out or obsolete parts and equipment—valves, pumps, pipe—then call your local scrap dealer. But don't stop there. Organize a program for regular scrap collections.



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ARMCO

(*Continued from page 98*)

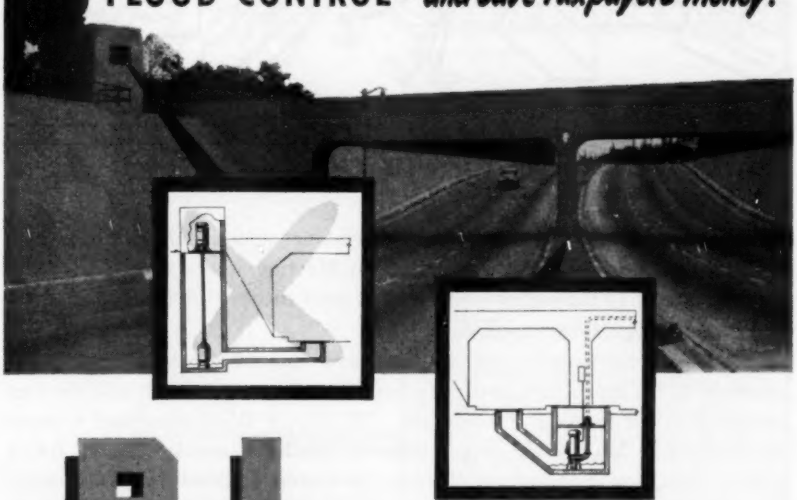
The belt gravimetric feeder for from 100 to 100,000 lb per hr of dry material is the subject of Bul. 35-F5B, a folder prepared by Omega Machine Co., 345 Harris Ave., Providence 1, R.I.

"Proportioning Pumps" is the title of a folder, Bul. 52, on that subject issued by Bird-Archer Co., 4337 N. American St., Philadelphia 40, Pa.

A portable service pipe cleaner—the "Water Wizard"—is described in a circular that may be obtained from Grayland Engineering Service, 5312 Grace St., Chicago 41, Ill.

"The Accelator" is the title of an 8-page booklet on water treatment for small supplies, ranging in capacity from 5 to 100 gpm. Distributed by Infilco Inc., Box 5033, Tucson, Ariz., as Bul. 1845, it discusses the operating characteristics and typical applications of the JBAS Accelator unit.

HERE'S HOW TO IMPROVE UNDERPASS FLOOD CONTROL—*and save taxpayers' money!*



BJ

SUBMERSIBLE PUMPS

save space, reduce installation cost, and eliminate the expensive pump house eyesore

Melting snow, heavy rains, and general water drainage are big problems in underpass flood control planning. This photo shows how you can meet these troublesome flood demands with new efficiency and at far less construction cost. The old standard pump house installation (at left), expensive and unattractive, can be replaced by unseen yet easily accessible BJ Submersible Pumps. These pumps are placed in a simply-constructed pit between highway lanes. They provide all the pumping capacity you need, yet use less than 1/10th the space required by a standard pump installation.

Plan your new underpass construction with BJ Submersible Pumps. And keep these space-saving pumps in your general water supply and water control program. For full details, specifications and capacities, contact your local BJ representative or send the coupon below.

Byron Jackson Co.

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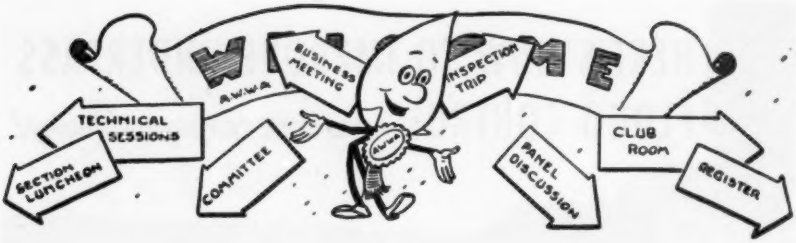
BUILDS THE BEST PUMP FOR YOUR WATER WORKS APPLICATION

DEEPWELL • LAKE AND RIVER INTAKE
BILTON • MULTIPLEX • HYDROPRESS
HYDROPLEX • TYPE S • VERTICAL
PROPELLER & OTHER CENTRIFUGAL PUMPS



Section Meeting Reports

Indiana Section: If enthusiasm, attendance and sustained interest are criteria, the 44th Annual Indiana Section Meeting was a success. It ran from February 13 through February 15 at the Lincoln Hotel in Indianapolis with a total registration of 392.

A happy combination of circumstances favored the section with the presence of the immediate past president, the current president and the vice president of the national Association. W. Victor Weir presented a paper on "Suburban Main Extension Policy" at the first session. A. E. Berry gave a luncheon address on "Water Resource Policies for a Nation." Charles H. Capen used a preconvention committee meeting as an excuse to come to Indianapolis, then stayed on to share in the deliberations and social activities. All three are highly successful ambassadors of good will.

In discussing Mr. Weir's paper, A. O. Norris, of the Indianapolis Water Co., remarked that unsound extension policies had converted many privately owned utilities into municipal utilities. He then gave his formula for a rational "free" extension, considering revenues, operational costs, investment for treatment and rate of return.

The Thursday morning papers were slanted toward industrial users who treat water to develop a more desirable product for boiler feed, cooling, or beverage purposes. Sam M. Paradiso, until recently superintendent of the Huntingburg Water Works and now power plant engineer with Eli Lilly & Co., of Indianapolis, stated that scale one ten-thousandths of an inch thick on a high pressure boiler could burn out tubes. He then enlarged on water characteristics and the internal and external treatments employed to adapt water for boiler uses. William M. Mingee, field manager, Bottlers' Service Dept. for the Coca-Cola Co., Atlanta, Ga., described the equipment and treatment used by his company to produce a uniform water satisfactory for their bottled beverage. His comment, "Regardless of the accuracy or exactness of the methods or the efficiency of the equipment provided, in the final analysis, the quality of the results obtained depends largely upon the

(*Continued on page 104*)

(*Continued from page 102*)

quality of the man who operates the equipment" can well be extended to more general applications in the water works industry.

One of the highlights of the technical program was a very practical and down-to-earth discussion of the materials situation under NPA by Gerald E. Arnold, director of the Water Resources Division, National Production Authority. Not only was his delivery audible, fluent and sincere, but his ideas were clear and he left his audience with the feeling that they actually understood a few of the things NPA is doing. "Ninety per cent of a pipeline or 75 per cent of a pumping station is no good to anyone," said Mr. Arnold. "You'll either get all or none, based on the evidence of need you can substantiate." He even promised a revised order before summer which would put all water works operation, inventory and construction regulations on one sheet of paper.

Robert N. M. Urash, geological engineer representing Carl A. Bays and Associates, Inc., read a joint paper which outlined the many tools available to the scientist who prospects for ground water. Resistivity measurements are but one source of data. Each should be used in its proper relation to discard areas that do not merit test drilling. Jerome Powers, division manager of the American Water Works Service Co., Inc., made some very pertinent comments on "Minimizing Hazards in Water Works Industry." "After an accident everyone rushes to give first aid, then the crowd argues about what happened. Too few actually find out what *caused* the accident or take steps to prevent a repetition."

The Manufacturers' Club Room was very successfully blended with the banquet festivities. Two hundred fifty members and guests dined together, received greetings from the national Association and from Canada, saw the Joseph F. Bradley Award presented to the Southwest area, heard H. O. Garman announced as a Life Member and H. S. Morse as an Honorary Member, and approved as T. J. "Tom" Burrin received the nomination for the George Warren Fuller Award.

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The final session was anything but an anticlimax. Melvin P. Hatcher, Director of the Kansas City Water Dept., held the Friday morning audience in close attention as he described his experiences with the flood last spring. His maps and slides were interesting and his general comments about preparing for similar disasters to the point. H. A. Kerby, A. G. Giannini, and T. J. Burrin, members of the special Highway-Utility Relations Committee reported on the practice of cost payment in Indiana when highway relocation requires construction or change of underground utilities. A state law places the burden of cost on the utility if its facilities are in a dedicated highway. Actually a system of waivers seems to leave no uniformity in enforcement. The proposed amendment to the federal roads law to permit payment was considered desirable but local action to set the Indiana house in order was recommended.

Herbert F. Zinsmeister was elected vice-chairman for the coming year; George G. Fassnacht was re-elected secretary-treasurer, and Lewis S. Finch began a three-year term as national director. Newly elected Chairman Oscar A. Newquist began his term of office by flourishing the gavel and adjourning the meeting.

George G. Fassnacht
Secretary-Treasurer

Coming Meetings

April **3–5**—Arizona Section at Maricopa Inn, Mesa. Secretary: Harry S. Jordan, San. Engr., Bureau of Sanitation, State Dept. of Health, Phoenix, Ariz.

11–12—Montana Section at Northern Hotel, Billings. Secretary: Arthur W. Clarkson, Assistant Director, Div. of Sanitary Engineering, State Board of Health, Helena, Mont.

16–18—New York Section at Hotel Syracuse, Syracuse. Secretary: R. K. Blanchard, 50 W. 50 St., New York 20, N.Y.

AWWA 1952 ANNUAL CONFERENCE
Kansas City, Mo.
May 4–9

Reservation forms have been mailed to all members, and all reservations will be cleared through the AWWA office. The hotels have agreed to accept no reservations for the 1952 Conference except as they are requested on the standard form prepared by the AWWA.

Accommodations at Fourteen Hotels

All Technical Sessions and Exhibits at Municipal Auditorium

(Continued on page 110 P&R)

Coming Meetings

(Continued from page 108 P&R)

April **17–18**—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary: E. Bruce Meier, Asst. Prof., Univ. of Nebraska, Lincoln.

24–26—Pacific Northwest Section at Davenport Hotel, Spokane. Secretary, O. P. Newman, Box 548, Boise, Idaho.

May **3**—Kansas Section at Town House, Kansas City. Secretary, H. W. Badley, 640 Highland St., Salina, Kan.

6—Kansas Section Business Meeting Luncheon at Hotel President, Kansas City, Mo. Secretary, H. W. Badley, 640 Highland St., Salina, Kan.

6—Missouri Section Business Meeting Luncheon, at Hotel President, Kansas City. Secretary, W. A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

26–28—Canadian Section at Mount Royal Hotel, Montreal. Secretary, A. E. Berry, Director of San Eng., Parliament Bldgs., Toronto 2, Ont.

June **18–20**—Pennsylvania Section at Lawrence Hotel, Erie. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg, Pa.

25—New Jersey Section Summer Outing. Luncheon at Martinsville Inn, Martinsville. Inspection of Elizabethtown's Millstone-Raritan Filter Plant.

AWWA ANNUAL CONFERENCE

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Reservation forms have been mailed to all members, and all reservations will be cleared through the AWWA office. The hotels have agreed to accept no reservations for the 1952 Conference except as they are requested on the standard form prepared by the AWWA.

4 major reasons why Permutit is WATER CONDITIONING HEADQUARTERS

WATER CONDITIONING HEADQUARTERS for 40 years, The Permutit Company pioneered in the application of ion exchange in water treatment. Permutit's *complete* line of water conditioning equipment is engineered to meet all needs.

1. **PRECIPITATORS**—A reaction and settling tank requiring less space, less chemicals and less time than previous designs. Permutit Precipitator softens water... removes impurities . . . lowers alkalinity content. Available in sizes having daily capacities from *one thousand* to *ten million* gallons.

2. **ION EXCHANGERS**—Hardness in municipal water supplies is objectionable because of its scale-forming, soap-destroying properties. Hardening elements can be *simply* and *cheaply* removed by passing water through tanks containing Permutit Zeolites. Softening occurs when Zeolites attract hardening ions—calcium and magnesium—and exchange them for sodium ions.

3. **SPIRACTOR**—A *space-saving* cold lime-soda water softener with a new principle—*catalytic precipitation.* Hard water plus chemicals enter shell and swirl upwards through catalyst granules. Precipitates deposit on granules by accretion . . . fall to bottom . . . are drawn off and *easily* disposed of. *Total reaction time is 8 minutes.*

4. **MONOCRETE UNDERDRAIN**—Non-corrodible monolithic construction is rigid and inexpensive. Large laterals and header consist of conduits cast in concrete... assure uniform collection and distribution of water. Laterals are formed by inflatable rubber tubes which are removed after concrete has set. Porcelain extension stems, containing porcelain strainers, extend from header and laterals to concrete surface.

Write for further information on these and other types of water conditioning equipment to The Permutit Company, Dept. JA-4, 330 West 42nd St., New York 36, N. Y., or to Permutit Company of Canada, Ltd., 6795 Jeanne Mance St., Montreal.

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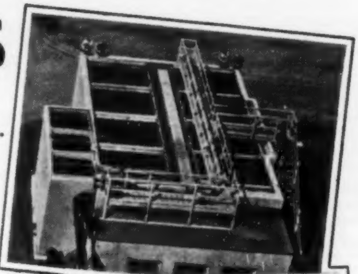

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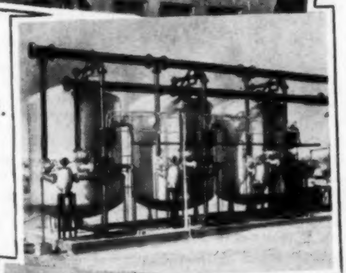

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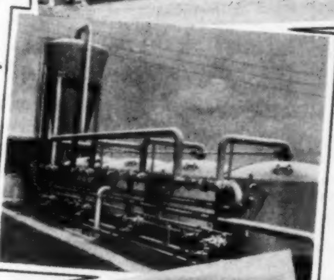

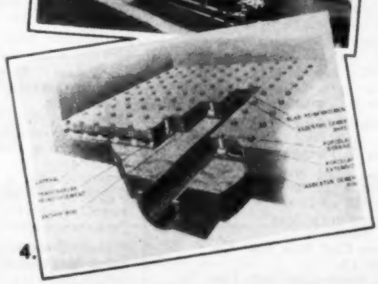

4.

PERMUTIT

WATER CONDITIONING HEADQUARTERS FOR 40 YEARS

Index of Advertisers' Products

Philadelphia Installs New Steel Water Line

Hundreds of feet of Bethlehem Tar-Enameled Pipe await installation at entrance to Fairmount Park, in Philadelphia.

Left to right: E. Haeger, contractor's foreman, A. Di Sandro, of A. Di Sandro Contracting Corp., and Joseph A. Thompson, engineer-inspector for Philadelphia Water Bureau, discuss job detail.

To improve its water-distribution facilities in the mid-city area, the City of Philadelphia recently installed a 6350-ft steel water main. The line extends from the Girard Avenue Bridge, through Fairmount Park to 21st St. It consists of 54-in. and 48-in. Bethlehem Tar-Enameled Water Pipe, coated on both surfaces, and wrapped with asbestos felt. The installation was handled by A. Di Sandro Contracting Corp., Philadelphia.

WELL-LIKED BY WATER-WORKS ENGINEERS

Bethlehem Tar-Enameled Water Pipe is the favorite pipe of leading water-works engineers for these reasons:

(1) It is leak-proof and bottle-tight, and maintains high flow coefficients.

(2) Its 40-ft lengths make it easy to string.

(3) It has sufficient strength and resilience to resist the effects of soil movement.

(4) Its smooth, uniform layer of coal-tar enamel prevents incrustation and corrosion.

Bethlehem Water Pipe is made in all practical diameters from 22 in. i.d. Additional details are available from the nearest Bethlehem office.

Bethlehem Water Pipe shown as it is about to be lowered into trench. The 40-ft length of pipe is cradled in sling to facilitate handling.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM TAR-ENAMELED WATER PIPE

SEND for USEFUL PIPE DATA

We have an interesting folder which describes in detail how the use of arc-welded field joints reduced cost of a 20-mile steel water line in Minneapolis. Illustrated. Contains table of pipe weights. Send coupon for your copy.

Publication Dept, Room 1058
Bethlehem Steel Company Bethlehem, Pa.

Please send Folder 559, describing use of arc-welded joints in 20-mile water line.

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A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1950 Membership Directory.

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